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PROFESSOR KENNEDY'S ADDRESS TO THE MECHANICAL ENGINEERS.

PROF. KENNEDY'S presidential address to the Institute of Mechanical Engineers is somewhat pessimistic in its tone, for it brings home to electrical engineers some rather unpleasant truths regarding their proposals towards the extension of electric power.

The theme of the address chosen by the Professor naturally was one connected with his own practice, which, of recent years, has been largely in electric lighting. He endeavoured to impress on his audience "the way in which the electrical problem of to-day, in this country, presents itself from a mechanical engineer's point of view."

Such a subject is, of course, too vast to be handled in anything like a thorough manner in the short limits of an address. Electro-chemistry and electric heating were dismissed with a few words, electric heating being considered altogether impracticable from a commercial point of view.

The incandescent lamp was mentioned merely to point out the necessity for great improvements in lamps, the present ones giving only 5 per cent. of light, 95 per cent. being wasted in heat. On the question of power, Prof. Kennedy is apparently more familiar with the details of his subject. He divides the matter into three great sections: (1) Transmission of electrical energy from a distance, for whatever purpose; (2) Transmission to a number of isolated points, comparatively near together, for instance the tools in a factory; (3) Transmission for the purpose of traction. In treating this subject the speaker is not carried away, as many are, by imaginary possibilities of the future of electricity, nor does the great efficiency, adaptability, convenience, and cleanliness of the electro-motor, blind him to the fact that the electro-motor is not a prime mover analogous to a steam engine. Behind the electro-motor there must always be a dynamo and a steam engine, or some other prime mover.

It is only too true that the transmission of power by electricity to a distance is often discussed by over enthusiastic electricians on the basis that it is a positive advantage to transmit power from the longest possible distances. Transmission of power to a distance is not a question of much interest in this country, as there is little or no power to transmit. Large waterfalls are few, and it is perhaps cheaper to transmit the coals from the coalfields than to transmit the electric current. The second section of the transmission problem is one which could have been better placed before the Society by actual figures from examples in practice. A case of the employment of electric lighting and power in a large factory occurs to us. An alternative scheme, with shafting and belting, was drawn up; but it was found that the estimates for the electric transmission came out just the same as the cost for installing shafting and belts, including everything from the engine onwards.

The examples given by Professor Kennedy from large engineering firms, showing that the cost to them of power generally lies between 2 and 5 per cent. of their total costs, is not to be taken as a fair estimate of the cost of power to other power users who are not "large engineering firms"; the argument only proves that large engineering firms get their power very cheap, and therefore they should adhere to their present system. There are, however, many industries where more power is used and wasted than in large engineering firms, and in these the waste work in shafts, belts and gearing is nearer 75 per cent. than the 25 per cent. assumed by Prof. Kennedy. Still electricians must not count upon the disadvantages of the old style of factory driving by one large slow going engine driving all the shafting. High speed light shafting is now adopted, and small high speed engines applied, which work more economically.

In estimating the relative costs of electric and shafting transmission, it must not be forgotten that shafting transmission requires a specially strongly built factory, with walls sufficient to withstand the strains added by the shafting, while with electric transmission there are none of these strains and weights to carry, and a great power can be transmitted throughout a slight building.

On the whole question we are afraid the President is right in his views regarding electric power as being of no importance to the engineer in this country. In substituting electric transmission for belts and shafting, we only make a change from one indirect method for another equally indirect method. So long as electricians depend on the steam engine for the generation of current, the electro-motor has not much chance in the competition with steam, gas, and oil, engines for motive power purposes in cities in this country.

The third section, electric power for trains and tramcars, is very fully treated. In comparing a steam locomotive with an electric locomotive, we find the efficiency of steam placed at 80 per cent., and that of electric power at 35 per cent. Under the existing conditions of electric traction we believe these figures are fairly accurate.

The difficulty of getting the current to the motors on the cars is put forward, the overhead trolley wire being somewhat unreasonably condemned. Why Prof. Kennedy should hope that the trolley wires in this country should be made impossible, is not quite clear. In our opinion the trolley wire is less objectionable than a steam tramway locomotive, even with a Serpollet boiler as suggested by Prof. Kennedy, and is even less objectionable than a street locomotive with a gas or oil engine. The odour from an oil engine on a tramway would be intolerable, while the exhaust from gas engines would not add to the sweetness of our streets, or to the comforts of the dwellers along the line. There are, of course, places where the trolley wire is not permissible, but even with only 35 per cent. efficiency when compared with a steam locomotive's 80 per cent., electric traction on the trolley wire system is to be recommended for many places where horse and steam traction is now used. In street railway work the question of efficiency presents a very different aspect from that presented by the Professor. We have to compare the costs against horse traction, not against a large locomotive on railway lines.

Proceeding to review the problems in the supply of electricity for public lighting, the familiar load diagrams and their significance were duly pointed out with much elaboration, the general state of idleness of the plant being made clear, and the great size of the plant required for a small yearly output was also calculated, from all of which it would seem to us that the first and foremost great problem before the electrical engineer is the solution of the storage of electricity. After all that has been said and done, the generation and distribution of electrical energy, as practised and established under the guidance of mechanical engineers is not much to boast of. On reading the so-called problems put forward on this part of the subject, one almost feels inclined to look at the date of the address, lest we might have made a mistake, and taken 1884 for 1894.

The treatment of the subject relating to central stations and their engineering may have been designedly simple, superficial, and antiquated, considering he was addressing mechanical engineers, for there is not a single reference to any of the new and interesting, and certainly very important, proposals and improvements made of recent years. In the generation, distribution, and transformation of electrical energy, British engineers seem to have settled down in the fixed belief that no further improvements nor advances can be made, and having discovered a Willans engine, a dynamo, a three-wire system, and how to draw a load diagram, all the problems in electrical engineering can be solved by various combinations of these.

Imagine the reason given for the hindrance to the general adoption of alternating currents, namely, "that their measurement is much more difficult and troublesome" than that of continuous currents. Such a reason being interpreted into plain language, means simply that ignorance has hindered the adoption of alternating currents. What have our technical colleges and schools been about all these years? Surely they turn out men who can make measurements of alternating current and pressure, impedance, capacity and self-induction. We rather think the hindrance mainly arose from mechanical engineers, who setting up as advisers on electrical matters, failed to acquaint themselves with the science of alternating currents.

The problems connected with polyphase work, the application of electric power in mining, and to marine work, electric storage, and many other points equally interesting, were not touched upon.

Prof. Kennedy's audience must have concluded that electrical engineering was very much in its infancy, and electrical engineers are shown that the business open for them in this country lies in electric lighting only, and the appliances connected therewith. Motors, stationary or locomotive, are not wanted, for they cannot compete; the gas engine is said to be better for traction than any electric motor. Still we firmly believe that a revival of good trade, and the consequent increased demand for improvements, would bring forward many things not dreamt of in the worthy President's philosophy, and thereby increase the electrical engineer's sphere of activity, extending it beyond the mere competition with the gas works.

The way in which the problem of electrical engineering presents itself to mechanical engineers, as elicited by Prof. Kennedy, is not the way it is presented to electrical engineers. An enumeration of the present disabilities of electric power, and an explanation of the meaning of load curves found in existing stations, such as formed the

gist of this address, cannot in any way be taken as a statement of the problems at present before the electrical engineer. The great problem whether alternating or continuous currents are preferable is not referred to. Many of the central stations now in operation have been hastily decided upon, and with no provision for the future, while others have been badly planned. These undoubtedly present problems to the electrical engineer when he is called in to rectify the errors. The compulsory supply of a small area has much to answer for in this respect; it is responsible for the adoption of a stereotyped system coming into use in many places to the exclusion of other systems which might give better results. It is all very well just now and for a few years to come, to work on the systems now put down, but when the time comes for extension, and the public get tired of paying for the electric lighting of small parts of a town, a good many problems not noticed in this address will crop up, to be met by the electrical engineer and others.

REGULATION AND GOVERNING OF ELECTROMOTORS.

The letter of Mr. Ward Leonard, referring to our remarks on the analogy between electromotors and turbines, and to his new arrangement of motors and generators for governing and regulating power at variable speeds, induces us to go a little further into detail on the subject and also to examine closely the proposed scheme of Mr. Leonard.

The subject is one of first importance to the electric traction engineer, and our article on the "Heilmann Locomotive from an Electrical Point of View," was designed purposely to present the problems connected with the governing of electromotors at variable speeds in a compact and easily comprehended aspect; the turbine analogy is a perfect one and throws a bright light on the questions, and there can be no errors in applying such an analogy in explaining the laws which govern the transformation of energy in an electromotor.

The inward flow vortex turbine invented by Prof. James Thomson, and which was very lucidly described by Lord Kelvin many years ago, is the best example of a turbine acting exactly as an electro-dynamic machine. As pointed out by Lord Kelvin, it is almost self-regulating at constant speed, the counter-force due to the centrifugal action tends to, and actually does, check the inward flow of the water, so that when acting as a motor this turbine presents the same phenomena as the electromotor, and its speed is governed by this counter force; like the electromotor, this turbine is also reversible, if it is driven by power it will act as a centrifugal pump and produce an external current of water. In fact, we may say, broadly speaking, there is an exact hydraulic analogy for every electrical phenomenon, and it is perhaps more strikingly complete in the case of the electromotor than in any other. We have reversibility and counter-force, and, considered relatively to the impressed force, this counter-force is the measure of the efficiency whether the motor is a turbine or an electromotor. Electric-power and water-power are both equal to the product of the pressure into the current.

Mr. Leonard's motors act exactly as all other motors. His invention does not disclose any new principles in motors. His invention is simply a combination of motors and generators of the ordinary type, whereby he transforms the pressure of the supply current, so that, to use his phrase, "you vary the volts as the speed desired, and vary the ampères as the torque required." There is no new principle or practice in this scheme, for in the earliest tramway electric motors which we can recall to mind driven by storage batteries, the batteries were grouped in parallel and series to vary the volts as the speed and the ampères as the torque, this being done by a combination switch.

This method has also long been the practice in driving alternating motors, it being so easy to vary the volts and current alternating at ordinary frequencies by a simple transformer or choking coil. Mr. Leonard's motor-generator-motor system could never compete with the ordinary transformer in changing volts and ampères while handling alternating currents.

But neither storage batteries nor alternating motors have been much used in traction work, hence in considering the general question we directed our remarks principally to the methods in most extensive use—the constant pressure supply with rheostat regulation.

Although Mr. Leonard's invention is not new in principle, the principle having been put into practice long ago by other inventors by other means, yet we very much admire his method; it is ingenious, and certainly carries out the object of his invention with efficiency by very simple means.

We cannot however grant all that is claimed for it. We admit that it will save all the energy hitherto lost in regulating by main current rheostats when variable speeds are required on electromotors, and this lost energy is a very formidable amount in electric railways, electric cranes, and other electric power machines which are constantly being stopped and started under heavy loads. That, in our opinion, is the chief improvement in the invention, with, of course, the concomitant reduction in engine, dynamo, and conductor capacity required in the system generating and distributing the current.

The assumption that railway cars are to reduce their speed inversely as the grade, is not practical. If we allow the cars to run full speed on levels, and to crawl up the grades, then this system would show great saving over the ordinary one, because the power would be no greater than on the level with the speed reduced in proportion to the rise in grade, a condition just suitable for the new system, while on the rheostat regulation, great power would be lost ascending at a slow speed. Cars must, however, be fitted with motors sufficient not only to start them on a grade, but to go up at the same rate as on the level, or at any rate at no great diminution of speed. The power required to carry the full load up the steepest grade, at a certain minimum speed, determines the important question as to the size and capacity of the motor-generator and motor on a street railway worked by the new plan.

The motor-generator may, of course, run at high speed and be thereby reduced in size; but still all three, motor-generator and motor, must be equal in power, and capable of doing the work we state on a grade.

In other columns we give a short description of the system, with some figures relating to the working of it in practice. It will be noticed that it is not an automatic method, and altogether depends for its efficient working upon the intelligent care of

the motorman, who must adjust the field rheostat to govern the current at starting, or in climbing a grade; and herein, we think, lies the weak point in the scheme, for if a quick start is to be made the motorman can turn on all the power and waste it just as he does in the present practice, and the big currents required for quick-starting will necessitate the use of large motors and generators. The method would show to greatest advantage with slow starts, and slow climbing of grades, whereas the present practice shows best with quick starts and quick climbing.

The great weight of all mechanically driven cars carrying motors is a difficulty, and we are afraid the new method may rather increase the weight of an electric car. The maintenance of the permanent way is a serious item in street railways with heavy cars driven by air, steam, or electricity. In street railways using these powers exceedingly heavy rails have been found necessary; anything which would lessen the weight of the cars would be a great benefit. If we take a car with motor power sufficient for the maximum work, and add a generator sufficient to supply current for the said work, and then add another motor capable of driving this generator, it comes up to quite a considerable tonnage. We are assuming that it requires the same power to run a car fully loaded on a level at full speed, or up an incline at a given speed, however it is driven; and on that assumption we calculate the weight of the car, with the additional machinery, will be greater than other ordinary electric cars.

The proposal to employ the motor generator only at starting or on slow speeds is excellent; it would then be quite a small machine with an output of, say, only 6,250 watts. But this plan necessitates a jump from quarter to half speed and from half to full speed, and, in the interval of time occupied in acceleration, the current would be, to some extent, wasted by the sudden rush on throwing over from one speed to another; this difficulty has been met with in mechanical variable speed gearing on tramcars, wide variations in current occurring at each change in speed.

To apply this new scheme to the Heilmann locomotive it would only be necessary to add another dynamo to act as a variable pressure generator between the steam-driven dynamo and the motors, but whether that locomotive is worth improving is very questionable.

The Electrical Conductivity of Flames.

An exceedingly suggestive line of research has recently been opened out by De Hemptinne, the subject of which is the electrical conductivity of flames. The fact has been recognised for a long time, but hitherto its bearings have not provoked much enquiry. De Hemptinne has now started on an investigation to determine the electrical conductivity of flames, which are heated gases, and of gaseous mixtures at the moment of union or of dissociation. The apparatus used in these preliminary researches consisted of two platinum electrodes, one connected with a voltaic cell, and the other with a capillary electrometer, so arranged that whenever a conducting medium was brought between them, the mercury in the electrometer became of lower potential and moved upwards in the capillary tube. When these electrodes were placed in a mixture of nitrogen dioxide and oxygen gases in the act of combining, no effect was perceptible even when the E.M.F. employed was 100 volts. The result was equally negative when hydrogen bromide and chlorine, and hydrogen chloride and ammonia were employed. When, however, the electrodes were placed in the same relative portion of a Bunsen flame, when the combustible gases contain variable quantities of an indifferent gas, the hydrogen flame and the carbon monoxide flame were found to exhibit good electrical conductivity, which increased as the temperature was raised. The experiments on the electrical conductivity of explosive mixtures at the moment of explosion, showed that in the case of oxygen-hydrogen and chlorine-hydrogen mixtures, there is a decided amount of conductivity, which in the case of oxygen-carbon monoxide it exists, though in a much less degree. Moreover, although hydrogen, chloride, and ammonia show no conductivity when uniting, at ordinary temperatures dissociating ammonium chloride conducts fairly well, as also does disssociating ammonium bromide. The vapour amylene bromide, however, though dissociating, does not conduct. Further details of this investigation may be found by consulting the original paper, which is published in the *Zeitschrift für Physikalische Chemie*, xii., p. 244.

Iridium by Electro-deposition.

Iridium has hitherto resisted attempts to deposit it electrolytically with any success, and this fact has seriously hindered its development as an industrial metal. To obtain it at all it has been necessary to prepare expensive chemical methods, for the strength of an electrolytic bath cannot be maintained by the dissolution of an iridium anode in the ordinary way. W. L. Dudley has recently discovered (*vide Amer. Chem. Jour.*, xv., p. 274), that the strength of the electrolytic bath may be kept constant by surrounding each anode (a carbon plate) with a loosely-fitting linen bag containing Ir $(O H)_4$, the acid liberated at the anode being thus immediately neutralised. The salts suitable for use as electrolytes are sodium iridiochloride, ammonium iridiochloride, and the double sulphate of iridium and ammonium. Iridium has a considerable tendency to form blisters in depositing, and needs care in the adjustment of the current density. It is only fair to say that this method has also been discovered independently by W. H. Wahl.

Electricity and Gas: a Hint from Our Rivals.

When we consider what has been accomplished in electric lighting during the past few years, we may well "prean our feathers." We must not be content with these self-complacent, though natural, emotions. That is precisely one of the reasons why the gas-monopolists made no progress for so many years. *Satis superque*—"Enough and more than enough" was their retort when the unhappy consumer ventured to suggest that the companies were not doing sufficient for him. This old saying does not reflect their attitude now; indeed, they manifest a feverish desire to conciliate those whom they heretofore contemned (except as a source of dividend), and they exhibit the greatest activity in developing and adopting new improvements. In our confidence in the future, we may exclaim with the late laureate, their "little systems have their day: they have their day and cease to be;" but however truly this may be applied to the gas interests, it will not do for us to encourage this spirit in our midst. Rather should we note the enterprise and energy of our rivals, and do our best to outrival them. Recently they have undoubtedly succeeded in so treating their incandescent lights as to be able to impart to them any desired tone of colour, from the purest white to the most intense yellow of the incandescent electric light. Moreover, they accomplish this with a production of heat only one-fifth of that developed by the old fish-tail burner. Hitherto we have produced coloured electric light, commercially, by a free use of tinted shades. Surely this does not represent the limit of our ingenuity in this direction.

THE THEORY OF HAIL.

O. Marangoni, writing in the *Transactions of the Royal Lincean Academy* and in the *Nuovo Cimento*, has discussed the genesis, the structure, and the morphology of hail, a phenomenon in which electricity plays an important part.

After criticising the theory of Volta, he expounds his own views. A hail-cloud is drawn out by the wind in the form of a horizontal tongue. By its rapid evaporation there is produced an intense cold. Thus there are formed flocks of dry snow which, by friction against the minute drops of water become, according to Faraday, charged with negative electricity, and are then attracted by the positive electricity of the drops of water. The snow flakes behind the cloud, *i.e.*, to the windward, are covered with a layer of ice, at first dry and then moistened. At the same time, according to recent researches of Lenard, which have appeared in Wiedemann's *Annalen* (Vol. xlvi., 1892), they are charged with positive electricity, and are driven in an outward direction by the positive electricity of the rain drops. Thus being cooled below zero and breaking through the cloudy stratum, they become charged anew with negative electricity, are coated with a new snowy layer and are again attracted by the cloud. Each hailstone, taking a wavy line, becomes enlarged by coating itself with alternate layers of opaque and transparent matter, and is ultimately thrown to the right or the left, occasioning thus the roaring noise which precedes the fall of hail, which then takes place in two parallel bands, separated from each other by a region of rain. These views agree well with the structure of hailstones as often observed, and with narrow linear extension of the hail over belts of country, and with the generally short duration of the storm.

As regards the structure of the hailstones, the author notices the existence of a gradual passage from snow to hail. He does not, however, seem to consider the fact that hail often accompanies a westerly or south-westerly wind (equatorial current), whilst snow rarely, if ever, occurs except along with a northerly or easterly wind (polar current).

Some of the forms of hail studied fall without lightning, but with a strong negative potential, whilst the others are accompanied, in proportion to their size, with lightning and thunder.

It may be permissible to regret that the awkward word "lightning" has now become definitely established in our language in place of the good old terms "levin" and "laite."

THE EDSON PRESSURE RECORDING GAUGE.

This instrument, which has lately been reported on by the Committee on Science and Arts of the American Franklin Institute, consists of a metal base, A, enclosing beneath it a tempered diaphragm, C, so arranged that when the fluid enters the space, D, between the spring and the cap, E, forming the chamber, the spring is deflected upwards.

The recording apparatus is mounted on the top of the base, A, and the movement of the diaphragm, C, is transmitted through the arms, H^2 and H^3, on the rock shaft, H, by means of the connecting bar, G, to the vertical moving pencil carrier in front, describing about six times the original travel of the diaphragm. Simultaneously therewith, the same rock shaft, H, moves the hand, M^2, before the dial, M.

A special clock mechanism revolves the receiving reel, K^2, contributing the element of time to the chart drawn from the reservoir reel, K, on the right beneath the recording pencil.

Ordinarily this reservoir reel, K, contains a supply of charts for thirty days. A glass dome surmounting the whole allows inspection and excludes dust, moisture, &c. The supplemental adjustable arm, O, upon the rock shaft, H, acts as a circuit-closer for an electro-magnetic alarm, and operates a mechanical alarm usually provided with each instrument.

This style of recorder has been found successful in recording pressures from two pounds per square inch, for blast furnaces, to 1,200 pounds per square inch, used in pumping oil.

For recording temperatures of drying-rooms, &c., a supplemental diaphragm is employed to increase the travel, owing to the low coefficient of expansion of the fluids used.

The latest style of instrument has no hand or dial, and in its construction the employment of mechanism, H, H^2, H^3, and H^4 is avoided, as also the hand and dial and corresponding rack and pinion, reliance being placed upon the small vertical scale standing immediately over the chart, which is

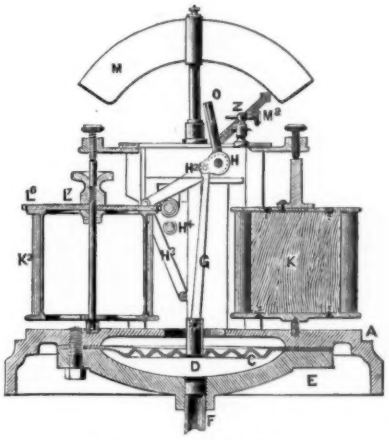


Fig. 1.—Sectional View.

ruled precisely as the chart is, and corresponds precisely with the travel of the spring. Its indications are more accurate than those at the end of the pointer-head on the segmental arc in the old style of recorder, for the reason that some lost motion is possible in the mechanism required to change the direction of, and multiply the motion derived directly from, the diaphragm spring. The office of the Edson recorder is not that of an *indicating* gauge, but that of a *recording* gauge. Its extreme sensitiveness, resulting from large original travel, renders its more finely graduated dial even more reliable than a large dial with a pointer-hand moving with an enormous multiplication of the original spring travel, as in other styles of gauges.

A NEW POLYPHASE SYSTEM.

A new combination of transformers for converting two-phase currents into three-phase currents has been invented by Mr. Chas. Scott, an American engineer, the proposal having met with the hearty approval of Profs. Forbes and Rowland, and Mr. Chas. Steinmetz. It is claimed that while three-phase currents are best for transmission purposes, two-phase currents are best for distribution; hence, the *raison de être* for such an invention.

We fail to see the commercial importance of such a plan, while we fully recognise the great advantages of three-phase current for transmission of power; we rather incline to the belief in continuous current for distribution, three-phase current can easily be converted into continuous current, as has been demonstrated by Appolony, Hutin and LeBlanc, Rankin Kennedy, and others.

The conversion of a single-phase current into a polyphase current by a transformer or transformers is a more important problem awaiting solution, and one which would have a greater effect on alternating current work.

However, this invention of Mr. Scott's is one of great scientific interest, and is, in the words of Prof. Rowland, a beautiful invention; its nature may be gathered from figs. 1, 2, 3, and from the following extracts from Mr. Scott's paper recently read before the National Electric Light Association:—

"In considering the marked advantages of the two-phase system for distribution and of the three-phase system for transmission, it occurred to me that a combination of the two systems might secure the advantages of both in a combined system, and I have worked out a simple and effective method of accomplishing this result. It is well known that if two electromotive forces, differing in phase, be connected in series, that the resulting electromotive force will, in

general, differ in value and in phase from either of its components. If two electromotive forces differing in phase 90 degrees, be connected in series, the resultant electromotive force is represented in direction and magnitude by the hypothenuse of a right angle triangle, of which the two sides are the two component electromotive forces. Thus, in fig. 1

Fig. 1.

if A O and O B are two electromotive forces at right angles, and these electromotive forces be connected in series, the resultant is the line A B of different phase from either of the components. It is a simple matter to so proportion the components that O B is equal to one-half of A B, as shown in the diagram. In a similar manner it is readily seen that the same electromotive force O A may be combined with O C, which differs from it by 90 degrees (but is equal and opposite to O B) in such a way as to give A C equal to A B, but differing in direction. B O and O C added together give B C. The electromotive force B C may, therefore, be combined with the electromotive force A O at right angles to it in such a way as to give additional electromotive forces A B and C A, which, in connection with B C, give three equal electromotive forces 120 degrees apart. This is the relation of electromotive forces in the three-phase system.

"The application of this arrangement to transformers is illustrated in the accompanying figs. 2 and 3. The

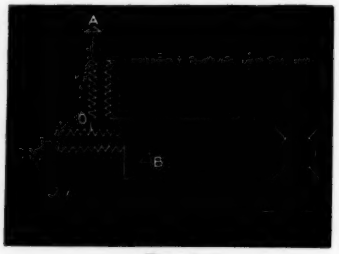


Fig. 2.

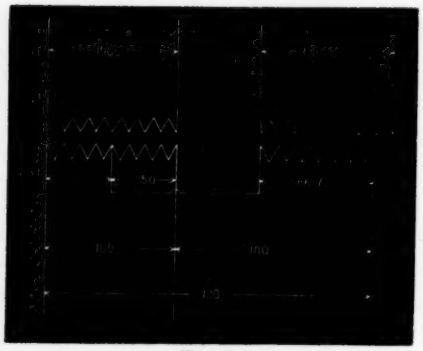


Fig. 3.

primaries of two transformers are connected to a generator giving two-phase current. The secondary electromotive forces therefore differ 90 degrees. One secondary is made equal to 100 turns, and a loop is brought out at its middle point, giving 50 turns at each side. The second secondary has 87 turns, which is approximately equal to 50 multiplied by the square root of 3. One end of the secondary circuit is connected with the middle point of the secondary of the first transformer, as shown, and the three free terminals will then deliver electromotive forces differing in phase 120 degrees. If the electromotive force on each primary be 1,000 volts and on one secondary 100 volts and on the other 87 volts, then the electromotive force measured between any two secondary terminals will be 100 volts.

"The efficiency of two transformers arranged for converting from two-phase to three-phase is reduced below that when working independently on ordinary loads by an insignificant amount. If the efficiency in ordinary working is, say, 97·5 per cent., it would be reduced to 97·4 per cent. in converting from one number of phases to the other."

By means of this invention, the Niagara Electric Company will be able to use three-phase circuits in their system wherever that may be found advantageous, but if it is held that three phases are better than two for transmission purposes, they should begin by generating three phases and transform into two phases or continuous currents. If Mr. Scott's arguments are correct the Niagara scheme reverses the natural order of things.

ON A SYNCHRONOUS ELECTRICAL MOTOR WITH AN ALTERNATING CURRENT.

Prof. Galileo Ferraris recently read a paper on this subject before the Royal Academy of Sciences at Turin, and has courteously forwarded us a copy of the document.

The method expounded in the memoir is supported on the three following propositions :—

A sinusoidal alternating vector may always be regarded as the result of two equal vectors, rotating the one towards the right and the other towards the left with the same frequency. The frequency of the two rotating vectors is equal to that of the alternating vector, and the constant magnitude found equal to the half of the amplitude of the same alternating vector. There are given two groups of vectors, and at a given moment they are : a, the magnitude of either of the vectors of the first group ; b, that of either of the vectors of the second group ; A, the momentary value of the vector resulting from all the vectors a ; B, that of the resultant of the vectors b ; ϕ the angle comprised between a vector a and a vector b, and φ (ϕ_1^2), the angle of A with B, when

$$\Sigma\, a\, b \cos . \phi = A\, B \cos . \varphi,$$
$$\Sigma\, a\, b \sin \phi = A\, B \sin \varphi.$$

Let a and b be two vectors rotating with the frequency m and n ; these frequencies may be considered as having the same sign or as having opposite signs, according as the rotations happen in the same direction or in opposite directions, and the angle is represented by ϕ, a function of the time which the two vectors make with each other.

Then if $m = n$ the products

$$a\, b \cos . \phi \text{ and } a\, b \sin . \phi$$

have constant values ; if m and n are unequal these products are variable and their mean value calculated for an equal time to a multiple of $\frac{1}{m-n}$ or for a very long time beyond $\frac{1}{m-n}$ it is equal to zero, or very minute.

A NEW SYSTEM FOR REGULATING MOTORS.

This system, the invention of Mr. H. Ward Leonard, has for its object the regulating of the power supplied to motors running at variable speeds, and stopping and starting frequently under heavy loads.

If a constant torque is required from no speed to full speed, it is well known that the volts at the armature terminals must vary as the speed ; and if more or less torque is required, we must vary the current. Hitherto the volts and current have been varied by the rheostat method—a very wasteful one. In using accumulators the variations can be made by grouping the cells, a very economical and efficient method ; and in using alternating currents, the variations can be made also with the highest efficiency by transformers or choking coils. The new method applies principally to working motors from constant pressure continuous current supplies. Fig. 1 represents a locomotive fitted with the new system. T is the trolley, M is a motor driving a generator, G ; the current generated by G drives armature, P, which drives

the locomotive. All three machines are excited direct from the main. The generator, G, has a rheostat in the field circuit, whereby the field strength can be regulated, and it will be obvious that the volts generated at G can be varied to any extent without any appreciable losses, by regulating the field of G.

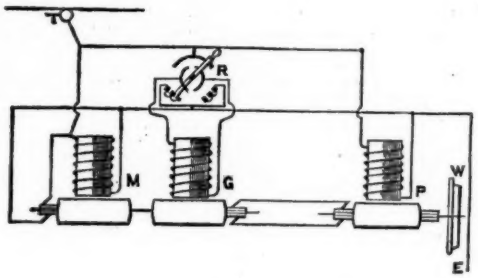


Fig. 1.

Following is a general description by the inventor of the arrangement proposed, as indicated by fig. 1 :—

Each car axle is driven by a gearless motor, either directly or by means of a connecting rod. The fields of these motors are excited directly from the constant E.M.F. of the line and independently of the armature circuit. Beneath the car and between the axles there is suspended a motor generator, each armature winding being in a separate field. The motor portion of the motor generator—which will, for convenience, be called the power converter—is shunt wound, and connected just as a shunt motor is for use upon ordinary constant potential circuits. The field of the generator portion of the power converter has its field connected across the line and has inserted in it a regulating and reversing field rheostat. This field circuit is independent of the armature circuit. The generating armature of the power converter is in metallic connection with the armatures of the gearless propelling motors. It will be noticed that this circuit, including the armature, is a distinct and separate metallic circuit having no connection with the line in any way.

Suppose now that our shunt motor is running at full speed, and that our controlling rheostat in the generator field circuit is at its central position, so that the generator field circuit is broken. Although the generator armature is being driven at full speed, it is revolving in a field having no magnetism, except the residual magnetism, and hence produces practically no volts. Let us now move our controlling switch so as to place the generator field across the line, but with a resistance in series with the field of 10 times the resistance of the field coils. We now give a slight excitation of the field, and a development of volts at the brushes of perhaps 40 volts. This voltage will produce a current through the armatures of the driving motors, dependent upon the ohmic resistance of this circuit only ; and hence, even at this low voltage, a large current will be produced, which, being in a field of full strength, will cause a torque sufficient to start the armature. The speed of the armature will, of course, be governed by the counter E.M.F. which its revolution produces in its strong field ; and hence, just as in the case of a shunt wound motor, its speed will be practically constant so long as the E.M.F. supplied is constant.

If we now gradually increase the magnetic field of the generator by cutting out resistance by moving the controlling switch, we will gradually raise the E.M.F. of the armature circuit, and with it the speed of the driving motors. Since these armatures are revolving in a constant field, the torque they produce will be exactly proportional to the current in them, and the current will automatically flow exactly as is required to produce the necessary torque to maintain a speed such that the counter E.M.F. will approximately equal the E.M.F. supplied by the power converter. Thus it will be seen that the speed of the car will be dependent upon, and proportional to the E.M.F. supplied by the power converter, and the torque or tractive effort will be dependent upon, and proportional to, the current supplied by the power converter.

Let us suppose that 60 amperes flowing through the armatures in fully excited fields will produce a torque sufficient to move the load when upon a grade. It is evident from what we have seen that 40 volts from the power converter will produce this current. Hence, by an expenditure of 5,400 watts in the secondary circuit, or a total power, including field excitation, &c., of about 8 H.P., we can start a fully loaded car upon a grade.

Under the existing systems we would need the same 60 amperes in the same fully excited field, but would necessarily use the full voltage of 500 volts, and therefore consume energy represented by 30,000 watts, as against possibly 6,000 in this system. The current from the line in starting the car under ordinary conditions by this system would be about 12 amperes at 500 volts, instead of from 60 to 100 amperes at 500 volts.

In practice, the controlling switch lever can be instantly thrown from its central position to its extreme position for full speed. The field magnetism of the generator is rapidly increased, and consequently also its E.M.F., which in turn causes a gradual acceleration of the car.

The current in the armature circuit, and consequently the torque, is quite large in the beginning ; but the E.M.F. at this time is quite low, so that the total watts are low. As the inertia is overcome, and the counter E.M.F. begins to approximate to the impressed E.M.F., the current falls off, and finally becomes constant at an amount necessary to produce the torque required to maintain the speed. The current from the line, and hence the power, gradually increases from zero to the amount required at full speed, but at no time, either at the start or during the acceleration, is the energy from the line greater than that required when we are operating at full speed. It will be noticed that the effect is the same as though we first operated through a set of gear wheels, giving an extremely great reduction of speed, and then rapidly changed the ratio of gearing, until finally we operated at full speed, with no reduction.

With our hypothetical gears we could, when running at speed, rapidly increase the ratio of gearing, so that the movement of the car would tend to drive the shunt motor faster and faster. This would convert it into a generator, forcing current back into the system, which production of electrical energy would act as a brake, and gradually bring the car to rest.

Just so, if, while running at full speed, we suddenly place our switch lever at its central position, the field of the generator will gradually reduce the strength, and the counter E.M.F. of the propelling motors will soon exceed that of the generator. The momentum of the car will now be driving our gearless motors as generators, which will supply current to the former generator, operating it as a motor, causing it to drive the shunt motor coupled to it as a generator, which, in supplying energy to the line, will act as a brake, and smoothly but rapidly bring the car to rest by converting the energy stored up and represented in the movement of the car into electrical energy, which will tend to relieve the work at the central station. Similarly, a car descending a grade and tending to accelerate in speed, can be made to move at any desired speed without the aid of any mechanical brakes, and the energy represented by its falling weight will be converted into electric energy and the car will become a moving feeder supplying energy to assist the generators at the central station in the operation of other cars.

It will be evident from what has preceded, that with this power converter system we can propel a car upon any practicable grade with a consumption of power no greater than is required to operate the car at full speed upon a level, by merely reducing the speed to the required extent.

In street railways of from five to ten cars, this is of great importance, for it means that we can equip a road with about 6 H.P. per car, as regards the engines and dynamos, and that our conductors can be reduced to about one-third of the amount at present necessary, for we will never require more than 20 amperes at the distant point, where to-day we have to provide for 60 amperes, with the same loss and the same initial E.M.F.

Under the rheostat system, the plant is severely taxed when an unusual crowd must be moved from a certain point, and it is then, when it is of the greatest importance that no breakdown should occur, that it usually does occur. With this power converter system we could, upon a five-car road, start up and move with perfect safety 10 or even 20 cars from the most distant point on the road, though of course at a reduced speed, but the crowd would be handled with perfect

success and without subjecting any portion of the plant to any unusual strain.

In the large cities it is no unusual sight to see an electric car moving at the slowest possible speed for perhaps several blocks. Perhaps 12 ampères are required to obtain the necessary torque. This, at 500 volts, is 6,000 watts. The power required for this slow motion by the proposed system would not exceed one-fifth of this amount.

Following is a tabulated statement (Table I.) showing the results we may expect to obtain by this system in operating with fully loaded car under three different conditions:—First, at 12 miles per hour on level; second, at 3 miles per hour on 5 per cent. grade; and third, at 1 mile per hour on level.

Leonard System of Electrical Propulsion.

Table I.—*Duty of Car. Showing various Losses expressed in Watts.*

Various losses involved.	8 tons at 12 miles per hour on level. Full speed, ½ full torque; armature current, 10 ampères.			8 tons at 3 miles (or 5 tons at 5 miles) per hour on 5 per cent. grade. ¼ full speed, full torque; armature current, 60 ampères.			8 tons at 1¼ miles per hour on level. 1/10 full speed, ½ full torque; armature current, 10 ampères.		
	Power Converter.		Driving Motors.	Power Converter.		Driving Motors.	Power Converter.		Driving Motors.
	Motor part.	Gen. part.		Motor part.	Gen. part.		Motor part.	Gen. part.	
Field	250	275	250	250	60	250	250	25	250
C^2R in armature	160	60	60	250	2,000	2,000	20	60	60
Friction ...	60	60	120	60	60	30	60	30	10
Foucault currents, hysteresis, &c.	200	400	400	200	50	50	200	10	10
Total	670	795	830	760	2,170	2,330	530	125	330
Total watts wasted ...	2,295			5,260			985		
Watts of work done	4,000			6,000			400		
Total watts absorbed ...	6,295			11,260			1,385		
Ampères at 500 volts ...	12·6			22·5			2·8		

In arriving at the losses, as indicated, the motor part of the power converter has been assumed as having the following features:

E.M.F. 500 volts, current capacity for 10 hours' continuous duty, 15 ampères; resistance of shunt field winding, 1,000 ohms, armature resistance, 1·1 ohms.

The generator portion of the power converter and the driving motor are assumed as having the following features:

E.M.F., 500 volts; current capacity for 10 hours' continuous duty, 40 ampères; resistance of field, 900 ohms; armature resistance, 0·55 ohms.

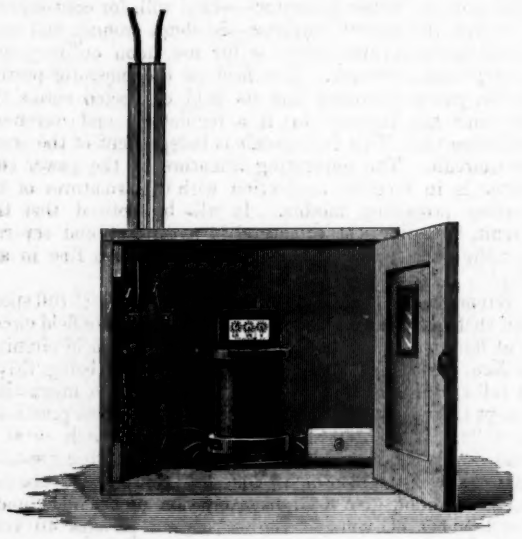
The rolling friction with gearless motors on good level track is assumed as 20 lbs. per ton. Car is assumed to be 8 tons in weight full loaded and 5 tons for moderate load.

We find that with 12 tons moving at 12 miles per hour on a level we will require 12·6 ampères, which is practically the same as by present series motor systems. With 8 tons moving at 3 miles per hour upon a 5 per cent. grade 22·5 ampères will be required, which is about one-third of the power required by present systems. With 8 tons at one mile per hour on level 2·8 ampères will be required, which is about one-fifth that of present systems. With 5 tons moving at 5 miles per hour on 5 per cent. grade 18·5 ampères will be required, which is about 40 per cent. of the power required by present systems.

The features of the proposed system which seem at first sight to be very objectionable are:—The increased cost of the car equipment, and the fact that we are adding an additional machine, having two fields, two armatures and three bearings; but, as we have seen, there is only an apparent increase in the first cost, for the saving in the generators and distributing plant far exceeds the additional cost of the car equipment; and the use of the motor generator for elevators, travelling cranes, &c., has demonstrated that, as regards the attention it requires and the depreciation it suffers, it has a marked advantage over the rheostat or commutated field used in the present methods of operation. We fear that excessive sparking will occur in the generator at low field powers.

A METER BOX.

There are several reasons, not to mention conveniences, why it is advisable to thoroughly protect electricity supply meters which are fixed on the premises of a consumer and which are intended to register the amount of supply. What these reasons are it is neither necessary nor wise to explain, and for the purposes of this description they may be considered as already admitted. Every manager of an electricity supply company will readily appreciate the advantages to be gained by the arrangement which is shown in the accompanying illustrations. He will, doubtless, understand the advisability of keeping an intelligent public from that little knowledge of electricity which is apt to be a very dangerous thing as far as the interests of the supply company are concerned. Moreover, similar reasons for protection also



apply to the consumers' terminals and to the company's main fuse, and on the low-tension system, which is the system at Hull, it has been found convenient to place these fittings together with the meter in one case. From the illustration which shows the case "open," it can be seen that the "record" can easily be read without opening the door. The slot shown in the door is covered by a piece of glass at the back, and the case is sealed up with a wire and a lead seal. In this arrangement no part of the main cables is exposed, and the casing containing them may also be sealed if desired. The idea of this combination originated with Mr. James Piggott, who is the outdoor superintendent and meter inspector of the Electric Lighting Committee of the Hull Corporation.

THE LIVET DESTRUCTOR.

On another page we publish a letter from Mr. George F. Priestley, one of the directors of the Livet Destructor Company, as we may shortly term it. Mr. Priestley finds fault with our article of April 13th. He fails to gather the meaning of the following sentence, for example, in which we refer to the enormous diameter of a furnace tube of

7 feet for a pressure of 160 lbs. per square inch externally applied.

We said: *What the thickness of the furnace tube may be is not given, but for so big a diameter it ought to be very thick in so slightly stiffened a flue, or else the safe pressure must be impracticably low.*

Considering that the drawing showed flanged seams at wide spacing, and no other provision, such as corrugations, Brown's ribs or Morrison rings, we feel that our remarks were justified. A furnace was shown that would not have been safe at any modern pressure, as Mr. Priestley may learn, if he will examine any suitable text-book, or ask any boiler insurance company. He will learn that the construction of a 7 feet flue tube is about as large an advance on anything yet done as the building of an Atlantic liner to cross in four days would be upon the *Lucania*.

The proportioning of large flues for high pressures is not quite so simple as Mr. Priestley would make it out to be. Not only is there the collapsing tendency due to buckling to be provided for, but there is the actual crushing stress, which amounts to nearly 14,000 lbs. per inch of length of the furnace—a little item which will have its due effect in demanding thickness, quite apart from the stiffening necessary to resist buckling.

Turning to the results claimed as secured at Halifax, our readers will observe that though it is duly stated that screened refuse was used, the general impression conveyed by the correspondence from time to time, and by the prospectus, has all been to the effect that refuse *per se* was equivalent to so much good coal, the favoured claim being, we should say, as nearly as it can be selected from a crowd of contradictory figures, a ratio of three to one.

Mr. Priestley in his letter distinctly states that under favourable conditions 1 lb. of refuse will evaporate 4 lbs. of water. Now what does he mean by this? Does he mean *refuse* or does he mean *screened refuse?* Why, when Mr. Perry F. Nursey was reading the barometer at 29·5′, the thermometer at 43°, and the wind velocity at 658 feet per minute, did he not give the proportion of "*dust*" sieved out of the refuse, so that we could for ourselves have figured out what 3·84 lbs. of evaporation per pound of screened refuse was equivalent to per pound of unscreened, or "straight" refuse. We are presented with none of this; yet we have the speed of the draught in each ashpit and furnace, items that might have had more weight had the area of ashpit opening been given also.

Not content with the test result of 3·84 lbs. evaporation, however, Mr. Priestley forthwith claims that 4 lbs. will be obtained in everyday work—a better result than was got at a set test. He sticks to the grate area of 200 square feet. The drawing only shows 180 feet, and did not purport to be other than a matured design. It has four grates, each 6 feet wide by 7½ feet long, so that the rate of combustion of screened stuff will not be merely 22 4/16ths lbs. as claimed, but nearer 25 lbs., a large claim for dirty fuel.

All Mr. Priestley's figures are based on what are practically the results secured with high-class plant and material all round. We have still no greater hesitation in rejecting them. Throughout the whole promotion of this scheme, no one seems to have been able to get down to hard facts. Erroneous figures have been published, and tardily withdrawn. The refuse, for which so much is claimed, is not refuse, pure and simple. This fact alone is enough to subvert all the figures advanced to float the scheme. Nothing has been brought forward to show even a good reason for this destructor being worth sixpence more than any other furnace as a refuse destroyer and steam generator combined. Even if we grant that the evaporation was correctly deduced from a test of only five hours' duration, with water levels *noted*, and fires *guessed*, to finish equal to what they started, the same could have been done in any simple Cornish boiler with a flue-feed heater to give the equivalent flue length and the modern setting as to flue area.

However erroneous, as our correspondent says, may have been our assumptions as to the value of refuse, such erroneous assumptions do not alter one iota the very serious fact that a sum of £600,000, and an annual royalty, is asked for a furnace which at best will do no more than a half-dozen other furnaces that are free as air to all to use as they will. This is the crux of the whole matter. We grant that a 7 feet furnace tube is a fine thing for securing good combustion, but it can as easily be made equally as strong for a Cornish boiler.

Mr. Priestley's drawing is before us as we write this. We have seen many boilers and many furnaces, but never anything that more thoroughly betrayed the hand of the amateur in boiler design.

Again is it flaunted out that the plant is at anyone's disposal to make tests, and that the company cordially invite this. Why was not this done before issuing prospectus? Was there not a request actually made to the company by a contemporary for a chance to make the test some months ago, and does the company still adhere to their opinion that the public should be asked for money on a five hours' test basis.

Finally, as adding to the interesting collection of inconsistencies, it will be noted that the evaporation from and at 212° F. is given at 4·6 lbs., which is perilously near to half the result obtained from coal. A fifth, a third, and now nearly a half!!! Why not go in for equality, and save all this beating about the bush? As well suffer for a sheep as for a lamb.

We still continue to find the calculations "too ponderous," despite the particulars which our correspondent appears to think should be accepted as gospel, and we would impress on Mr. Priestley and his colleagues that the issue is not as to the value of refuse for fuel, but as to the value of the Livet destructor compared with other furnaces. Mr. Priestley tries to drag a red herring over the scent in so persistently arguing that refuse has a value. No one denies it has a certain value, but such value gains nothing whatever by any furnace Mr. Priestley and his colleagues have to offer.

ELECTRICAL SANITATION.

A GREAT stir is being caused just now in industrial and hygienic circles by some recent experiments in the purification of sewage matter by means of electricity, according to M. Hermite's process, which consists, as we know, in treating the excreta before they are conveyed into the drain, with water that holds in solution the chlorides of sodium and magnesium, and that has been subjected to electrolysis. For some months, says M. Georges Vitoux in *L'Electricien*, M. Hermite has been trying his system of disinfection in various towns in both France and England, particularly Havre, L'Orient, Brest, Nice, Worthing, and finally quite recently at Paris itself, at the offices of *Le Figaro*, which for several weeks have been publicly subjected to the electrolysed chloride water treatment.

Such experiments multiplied in this way are far from being valueless to the community, their importance being in proportion to that of the problem to be solved. And is this problem so very complex after all? The question is how practically and safely to get rid of the enormous quantity of sewage matter produced every day without endangering the health of the community, and without unduly increasing municipal expenses.

Several plans have been tried.

One, the simplest and at the same time the best, or rather the least objectionable, consists in conveying the sewage directly to the sea by a covered air-tight drain. This method, although perfect from a hygienic point of view, has the drawback of being only applicable to localities near the coast, and moreover all the fertilising products are lost.

As to the system by which the sewage is all conveyed first to the main sewer, and finally emptied into the river or into the cesspools, which enable the solid matter to be separated from the liquid which serves to carry it along, it is attended with infinite danger to the public health, unless the costly precaution is taken of first sterilising by means of chemical disinfecting agents the entire mass circulating in the collectors.

We must not forget that numbers of bacteria, and especially the cholera and typhoid fever microbes, adapt themselves readily to an aquatic existence, and even find water an eminently favourable vehicle for their rapid dissemination.

With M. Hermite's process, on the contrary, the objections we have quoted no longer exist.

Moreover, the process is a very simple and practical one, being really a combination of the system by which every-

thing is conveyed to the sewer either with or without the liquid being drained off, with chemical disinfection which is effected—and herein lies the most essential point as regards the public health—immediately after the addition of any fresh sewage matter, which under no circumstances whatever can arrive at or circulate in the system of sewers without having first been completely sterilised.

To effect this M. Hermite subjects some sea-water to electrolysis, or in default of sea-water, an aqueous solution of chloride of magnesium and chloride of sodium. Under the influence of the electric current, the water and the salt are decomposed. At the positive pole we get an oxygenated compound of chlorine, very unstable, which possesses a considerable oxidising and consequently disinfecting power; at the negative pole an oxide is formed which has the power of precipitating certain organic substances. Thus, by this one operation, we get a liquid possessing the following properties:—

1. It completely destroys the organic substances resulting from putrefaction, and also the gases, such as sulphuretted hydrogen, hydro-sulphate of ammonia, the carburets of hydrogen, and also germs or microbes.

2. It precipitates certain substances, such as albuminoids, &c., and consequently clears the liquids.

This disinfecting liquid, when obtained, is sent instead of ordinary water into water-closets, sinks, gutters, and, in short, into all places where sewage matter is likely to be produced and to collect.

In short, then, M. Hermite's system requires a central station for the production of the electrolysed water, and a system of pipes for the conveyance of the disinfecting liquid to all those points where it is likely to be required.

In all cases the installations are of a similar nature, only differing in the quantity and power of the apparatus used, and the extent of the mains distributing the disinfecting liquid.

Installation of a Central Station.—As shown in fig. 1,

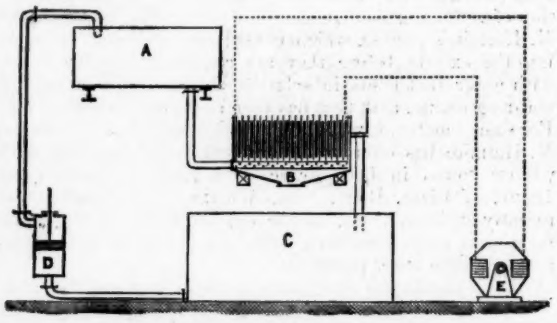


Fig. 1.—Plan of an Installation for Electrical Sanitation according to M. Hermite's System.

the plant of a central disinfecting station comprises a dynamo, E, generating the currents required for electrolysis; an electrolysing apparatus B, and a pump, D, which pumps sea-water or salted water directly into a trough, C, whence it is conveyed into a second trough, A, passing thence into the electrolysing apparatus, B, after which it falls back again into the trough, C, and is finally conveyed into the mains.

We will now examine each part of this installation. As to the electrolysers, which are extremely simple in construction, they have lately undergone important improvements, calculated to ensure their good working. We will, however, give a detailed description of these apparatus, as furnished by the inventor.

The electrolyser consists of a galvanised iron trough, at the bottom of which is a tube pierced with a number of holes, and provided with a zinc tap. It is through this tube that the sea-water or solution of chloride enters the electrolyser. The top of the trough, which is of galvanised iron, has a rim forming a gutter; the liquid flows into this, and escapes by a pipe. Thus a continual circulation is kept up.

The negative electrodes consist of a certain number of zinc discs, mounted on two axles, which turn slowly.

Between each pair of zinc discs are placed the positive electrodes (fig. 2), the active surface of which consists of sheets of platinum, wound on glass rods, 12 millimetres in diameter, the upper part of which is received into tubes of copper encased in tubes of ebonite, which are intended to protect the copper from any alteration. The various positive electrodes are connected together by a bar of galvanised iron, and each positive electrode communicates by means of this said bar of galvanised iron, with a bar of copper passing through the electrolyser, and in communication with the positive pole of the dynamo. The contact of the electrodes is ensured by means of a screw, and each electrode, which measures a total length of ·451 metres, the height of the free sheet of platinum being exactly ·351 metres, can be removed while the apparatus is working, without causing any interruption.

Fig. 2.—Positive Electrode of the Hermite Electrolyser.

Four of these positive electrodes correspond exactly to one negative electrode.

The current is distributed into all the platinum electrodes, whence it passes through the liquid into the zinc discs forming the negative electrodes, and communicating by the iron box with the negative pole of the dynamo.

In order to keep the negative electrodes perfectly clean, flexible knives of zinc are placed between the electrodes; these knives bear continually against the zinc discs, and as these latter slowly turn, any deposit formed on their surfaces is, of course, removed at once.

At the lower part of the trough is a door that can be opened for cleaning purposes; a tap enables the apparatus to be emptied when necessary.

Lastly, strong, simple measuring instruments, placed in the circuit, show at each moment whether the apparatus is working satisfactorily, and what force is absorbed. These instruments consist of an ampèremeter, a voltmeter, and a rheostat consisting of a series of German silver spirals of greater or less resistance, according to the types of dynamos employed. A special commutator, placed near the measuring instruments, enables resistances to be introduced or cut out, as required.

M. Hermite constructs three types of electrolysers, all on the same principle, however, and only differing from one another in the number of electrodes.

In type A there are 54 zincs and 208 platinum electrodes. This is the type best suited to industrial requirements. Type B, which is smaller and better adapted to installations on a smaller scale (factories, hospitals, &c.), contains 28 zincs and 104 platinum electrodes. Type C, which is smaller still, has only 12 zincs and 44 positive electrodes.

The current sent into the electrolysers of the type A is

generally from 1,000 to 1,200 ampères, and from 5 to 6 volts.

For type B, the current is from 500 to 600 ampères and from 5 to 6 volts, and for type C from 250 to 300 ampères and from 5 to 6 volts.

In important stations, where it becomes expedient to employ several electrolysers simultaneously, these instruments are connected in series, the positive pole of the first in communication with the negative pole of the second, and so on. Experience has shown that the maximum grouping that could be effected advantageously was 10 electrolysers worked by a single dynamo. Such an installation as this is sufficient to ensure the complete sanitation of a town of 20,000 inhabitants, including the watering of the streets.

The electrolysers require very little attention; about once a month the door at the bottom is opened and the apparatus is washed out with water by means of an India-rubber tube, without requiring to be taken to pieces. The positive electrodes are also lightly brushed.

The conductors connecting the electrolysers to the dynamo are bars of the pure copper of commerce. For small stations, M. Hermite has constructed complete apparatus capable of being transported bodily with the three types, A, B and C, of electrolysers, comprising on a single framework of limited dimensions, two troughs for receiving the chloride water to be electrolysed, a pump for effecting the circulation of the liquids, and lastly, a dynamo for the production of the necessary current.

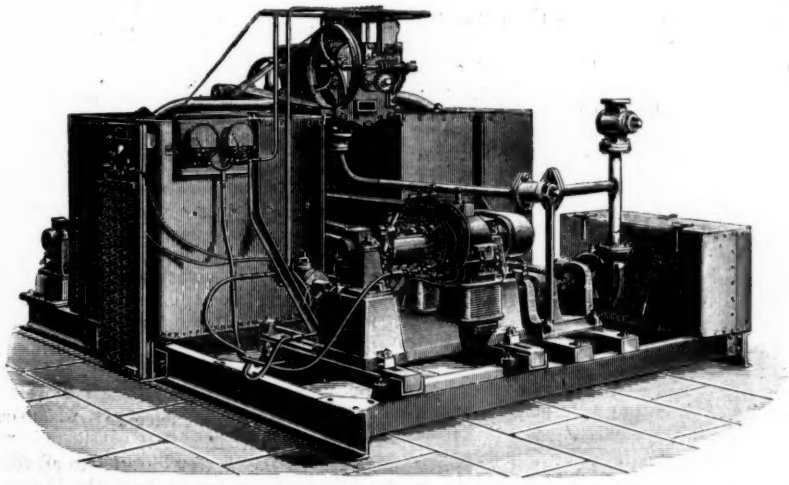


Fig. 3.—Electrical Sanitation (Hermite System) Installation of the Dynamo and the Electrolyser.

In the *Figaro* installation, which everyone in Paris is at liberty to visit, the service was effected by one of these transportable apparatus of the type C, the dynamo of which was put in action by a 6 H.P. petroleum motor of the Grob type, supplied by the Universal Motor Company, only half of its power being utilised.

This motor is fed solely with petroleum, which has the very important advantage over other carburetted liquids of always being of the same composition. The working of the motor is very simple. A little pump, worked by a horizontal axle deriving its movement from the axletree of the machine itself by means of a straight gearing, draws from a special reservoir the petroleum intended to feed the motor. A special arrangement, called the regulating valve, is placed at the top of the pump, which has both a lift and force action, and serves to regulate the quantity of petroleum which it is necessary to draw up for each explosion.

The petroleum, drawn up in this manner, is sent into the pulveriser, which is seen at the top of our figure to the left, and afterwards into the gasifier, which is kept constantly at red heat by means of a burner fed by a special lamp. It is in this gasifier that the mixture of the air with the gaseous petroleum takes place.

A valve worked by an eccentric fixed on the axle of the machine, serves to drive out the gases resulting from the combustion. The starting of the Grob motors, which consume only a half-litre of petroleum per horse-power per hour, necessitates the previous lighting of the lamp that supplies the burner during the few minutes required to bring the gasifier to red heat.

The Results Gained.—The rendering in chlorine of the electrolysers is somewhat high, and corresponds exactly to 1 gramme per ampère-hour, so that an electrolyser, A, working at 1,000 ampères, supplies per hour of work a cubic metre of disinfecting liquid at a strength of 1 gramme per litre, *i.e.*, at a degree of concentration far above what is really required in practice. Experience, in fact, has shown that the strength best suited to the requirements of the general disinfection of towns was ·5 gr. per litre of liquid. Also, as regards the cost of production of the disinfecting liquid, the strength of ·5 gr. per litre is most advantageous, as is clearly shown by the following observations made recently at Brest with the trial installation at the commercial port, and which are summed up in the official report addressed to the Municipal Council of Brest by Dr. Alain Piton, naval doctor of the first class, professor at the Naval School of Medicine at Brest, and formerly a pupil at the Pasteur Institute.

"According to the information given to me by M. Coudray," writes M. Piton, "the apparatus installed at the commercial port requires:—

"1. 4 hours 15 minutes, or 255 minutes to bring to the strength of 1 gramme 1,000 litres of sea water; in 24 hours, therefore, we shall get 5,640 litres at 1 gr.

"2. 3 hours, or 180 minutes to bring to ·75 gr. 1,000 litres of water; in 24 hours, therefore, we shall get 8,000 litres at ·75 gr.

"3. 1 hour 45 minutes, or 105 minutes, to bring to ·5 gr. 1,000 litres of water; in 24 hours, therefore, we shall get 13,700 litres at ·5 gr."

At the time of the experiments made last year at Havre, where the complete disinfection of a particularly unsanitary quarter, namely, the quartier Saint-François, had been undertaken, the installation comprised four electrolysers of the type A, and supplied 600 litres of disinfecting liquid per minute.

In short, speaking generally, it is shown by the various experiments made as yet that the Hermite system of electrical sanitation is a practical one as far as cost is concerned.

In all the seaports, after the cost of installation, the expenditure is limited to motive force, since the sea-water costs nothing and contains naturally, and in suitable proportions, the chlorides necessary for the production of the disinfecting liquid. But we must also note, and this is an important point, that by employing this sea-water we effect a considerable saving, as we no longer have to use fresh water for the cleansing of sewers, gutters, water-closets, &c., and thus the fresh water can be reserved almost exclusively for domestic purposes. In towns at a distance from the coast or from salt springs, the expenses will be increased by the cost of the

chlorides, which are indispensable. But these products are cheap, and at present, according to M. Hermite, we can guarantee that the expenses incurred in this way will not be considerable, and will allow of a considerable saving over the expenses of the systems now in force.

Thus, at Paris, where the cost of cleansing the sewers, water closets, &c., amounts to a minimum of 7 francs per annum for each inhabitant, only 3·6 fr. would be required by the Hermite process. As to the works and canalisation that would have to be established in order to effect the complete sanitation of the city, the whole installation would cost, at most, 60,000,000 francs.

The Disinfecting and Bacteriological Properties of the Liquid.—We now know the various conditions of the production and the cost of the disinfecting liquid prepared according to the Hermite process. To form a correct opinion as to the value of the system, we must know its exact disinfecting and sterilising power.

In the first place, we may remark in passing that this liquid—which, as we shall see presently, acts very powerfully on different bacteria—is harmless to animals of a higher organisation.

This fact has been verified by a conclusive experiment which is of real practical value, when we consider that, as a rule, the fæcal matter from towns is conveyed to the river along with more or less of the disinfecting liquid. For several months some gold fish which M. Hermite has in his laboratory have been living, without being in the least affected, in water to which a quart of the electrolytic disinfecting liquid has been added.

But with microbes, for instance, this is not the case, and the experiments made by various bacteriologists, the results of which have been, for the most part, confined to official reports, are particularly conclusive with regard to this point.

Another extract from Dr. Alain Piton's report which we quoted just now will enlighten us with regard to this.

This is, in fact, what Dr. Piton writes when summing up the conclusions drawn from the experiments with which he was charged by the Municipality of Brest.

"From all the experiments which I have made, it follows :—

"4. That the deodorising power of the electrolysed water is perfect.

"5. That its power of dissolving fæcal matter and paper seems to be nil.

"6. That in order to sterilise a mass of 150 grammes we require—

"*a*. 6 litres of water at a strength of 1 gr.
"*b*. 7 " " " " ·75 "
"*c*. 9 " " " " ·50 "
"*d*. 10 " " " " ·36 "
"*e*. 12 to 15 litres of water at a strength of ·25 gr.

"7. That the electrolysed water at 1 gramme sterilises liquid excreta of an equal volume in 5 minutes.

"8. That no more than 5 minutes are required for water at a strength of 1 gr. or ·75 gr. to sterilise an equal volume of pure cultivation of cholera or typhus bacilli.

"9. That 10 minutes are required for water at ·5 gr. to sterilise an equal volume of pure cultivation of cholera bacilli.

"10. That 15 minutes are required for the water at 1 gr. to sterilise an equal volume of pure cultivation of the *Bacillus subtilis*.

"11. That close contact is indispensable, hence the necessity for fixed tanks and flushing apparatus for washing the fæcal matter before it is conveyed to the drain.

"In short, the experiments I have made enable me to conclude that the electrolysed sea water is a perfect deodoriser and an excellent antiseptic, and that it rapidly destroys the most obstinate micro-organisms, that is, if there is close contact between the micro-organism and the electrolysed water."

As we see, Dr. Piton's report is singularly exact in its statements.

Our contemporary fervently trusts, in the interests of the public health, *i.e.*, in those of the welfare of the whole community, that these conclusions will not be contradicted hereafter.

THE OTTAWA CONFERENCE.

We are glad to learn that at the Colonial Conference which will be held at Ottawa towards the end of June, all the colonial governments interested in the advancement of the Pacific cable enterprise will be well represented, and that Her Majesty's Government will also take a part in the proceedings. In view of the generally recognised necessity for a cable across the Pacific, it seems unlikely that, as on a former occasion, the result of the deliberations of such a meeting (whatever that result may be) can be calmly ignored by Her Majesty's Government. That the establishment of such a cable supported by Government guarantees, or subsidies, is distasteful and irritating to those connected with the existing companies, and who are, therefore, antagonistic to the scheme, we can well believe. Indeed, this spirit was exhibited in an unseemly manner at a meeting of the Eastern Extension, Australasia and China Telegraph Company's shareholders, held last week under the presidency of Sir John Pender, who is chairman of that company. At this meeting a Mr. John Newton, a shareholder, after protesting against Government interference, is reported to have said (unrebuked by the chairman) : "You have shown us good reason why that cable is not wanted, although there is one reason, no doubt, why it is wanted, and that is for jobbery and corruption."

But almost all that was said at this meeting concerning a Pacific cable, may be disregarded. As to the opinions expressed by the chairman, these, as was recently pointed out by the Premier of Victoria, are the views of an interested person, and ought to be regarded in that light.

One remark made by the chairman deserves, however, some attention, viz., the statement that "as the existing system was established by private enterprise, without any Governmental assistance whatsoever, Her Majesty's Government could not in equity grant pecuniary aid to the proposed competing line without subsidising or guaranteeing our cables to, at least, the same extent." Now this is simply ungrateful. The Eastern Extension, Australasia, and China Telegraph Company are at present in receipt of annual subsidies from colonial governments amounting to £32,400 per annum : in this way they will have received in July next, Government aid to the total amount £486,000, add to this £75,000, the amount of 10 years' subsidy on the New Zealand-Australia cable, which, in addition to an annual grant equal to half the loss of receipts due to the recent reduction of tariff, makes a total of £615,799. We do not here take into account the amount received as subsidies for cables touching at Manilla, Maçao, Tonquin, and Malacca. This sum may be looked on as a very substantial assistance, when the value of the cables concerned is taken into consideration. Sir John Pender pointed out that the total mileage of the Eastern Extension, Australasia, and China Telegraph Company's system is now a little over 18,000 miles, and that the cost of the last 2,100 miles was about £300,000, or say, £143 per mile (for a new cable). Now, for the sake of argument, taking as new, say, 7,470 miles of cable laid during the last 10 years for this company, we get, at £143 per mile, a value of £1,068,210. On the same basis, reducing by 25 per cent. the value of 3,893 miles of cable laid between 10 and 15 years ago, we get, at £107 5s. per mile, a total of £417,524 ; and reducing by 50 per cent. the value of the remaining 6,629 miles which are more than 15 years old (and about 5,000 miles of which are not less than 20 years old), we get, at £71 10s. per mile, the sum of £473,973. Thus making together, for the 18,000 miles, a total estimated value of £1,959,707. Now, on this amount it must be admitted that the relief afforded by the £615,799 received from the colonial governments forms an extensive percentage.

It may be objected to the above figures (however liberal these are) that the values of cables given here have no relation to the prices paid for each of them ; but as these prices have almost all been arranged by private bargain, and have not been offered to competition in the open market, we have no means of examining the financing of these ; this could better be done by some shareholder in the property.

It is sufficient for us to point out, that in view of the assistance given to this and other companies, the Ottawa Conference should in equity arrange to place the Pacific cable on at least the same basis as the existing lines (of which the Eastern Extension, Australasia, and China Telegraph Company's cables form part) as far as guarantee and subsidy are concerned.

REVIEW.

Science Progress: A Monthly Review of current scientific investigation. No. 1, Vol. i.

This periodical, which is issued under the auspices of an editorial committee containing the names of some leading and representative scientific men, proposes to supply its readers with notices and reviews of the effective work that is being accomplished in the various branches of science. The articles are not to be mere abstracts, but critical expositions of the work done in each department. If this is thoroughly carried out, *Scientific Progress* will be a novel and important addition to our periodical literature. The different sciences are now so intimately correlated, that the specialist can no longer confine his attention solely to his own field; he must at least have a general knowledge of the new methods and results of other sciences that come in contact with his own. This point is well brought out and illustrated in the first article in this number on "Physical Science and its Connections," by Professor Fitzgerald. This transfer of information from one department of science to another is compared to blood-vessels and nerves, or to railways and telephones. Professor Fitzgerald's article consists principally of unanswered questions. "What is an electric current? What is a magnet? Is the earth rigid? What is the physical condition of nebulæ and of new stars? Why does light cause combination of hydrogen and oxygen? &c., &c." It shows, however, the vast problems the physicist has now to face. An excellent article "On the new theory of solutions," by W. J. Rodger, follows, containing an account of the interesting discoveries of Van't Hoff and others in this field. This number contains also articles on "Fossil Plants," by A. C. Seward, on "Insular Flora," by Hemsley, on "Bacterial Poisons," by Buckmaster, on "Vertebrate Morphology," by Howes, and on "Chemical Physiology," by Halliburton.

CORRESPONDENCE.

Livet Destructor.

Will you kindly allow me to reply to certain remarks contained in your leading article of the 13th inst., regarding "The Livet Destructor."

The ferrotype forwarded to you was not intended to represent a detail or working drawing, but merely for illustrative purposes, and to show the general arrangement of plant, your remarks therefore about the "thickness of furnace tubes" are misplaced; and surely the writer of the article must have understood that no difficulty need be anticipated in the construction of a perfectly circular fire-box, 7 feet 6 inches diameter, and for a working pressure of 160 lbs. per square inch. I therefore fail to gather the purport of the following:—

What the thickness of the furnace tube may be is not given, but for so big a diameter it ought to be very thick in so slightly stiffened a flue, or else the safe pressure must be impracticably low.

Now for results obtained by burning refuse, and mind you, refuse only, in the boiler at Halifax.

Date of test, February 23rd, 1894.	
Duration of test, five hours.	
Barometer	29·5
Temperature feed water	45° Fah.
Temperature feed water after passing through heaters	240° "
Boiler pressure	50 lbs.
Class of fuel:—Town's refuse screened so as to deprive it of dust only.	
Water evaporated	17,800 lbs.
Refuse burned	4,628 "
Water evaporated per lb. refuse burned	3·84 "
Equivalent evaporation at and from 212° Fah. ...	4·60 "
Refuse burned per hour	926 "
Refuse burned per square foot grate area per hour ...	22 "

Sufficient data is given in the above particulars to proceed with the 1,200 horse-power calculations which seems to have been too ponderous for the writer of the leader of the 13th inst.

4,480 lbs. refuse burned on a grate area of 200 square feet, equals a rate of combustion of 22·4 lbs. per square foot grate area per hour, surely not an excessive amount.

Under favourable conditions, 1 lb. refuse will evaporate 4 lbs. of water, therefore 4,480 × 4 = 17,920 lbs. water converted into steam.

With a boiler pressure of 160 lbs. per square inch, and a triple expansion engine, 14 lbs. steam per I.H.P. per hour may be assumed as a fair quantity, the horse-power therefore works out at 17,920 ÷ 14 = 1,280 I.H.P., a result which can be obtained and which is a fair deduction from the results of tests made upon the boiler at Halifax. Time and space forbid me following in detail the flounderings and calculations made from your erroneous assumptions as to the capabilities of the steam raising properties of refuse. The whole plant is at anyone's disposal to make tests and prove the correctness or otherwise of the tests given in the fore part of this letter, and the company cordially invite and offer every facility to anyone so doing.

Geo. F. Priestley.

[With regard to Mr. Priestley's last paragraph we would like to ask whether, in November of last year, the Editor of *Industries and Iron* did not arrange with Mr. Houldsworth (one of the financial supporters of the "Livet" Co.) to make some tests at Halifax? Also whether he did not see Mr. Cheesewright (the engineer) and Mr. Oliver (another of the financial men), and whether, in each case, he was not promised that a test should come off in December? Has not the matter been delayed from time to time under specious excuses, so that up-to-date no thoroughly reliable trial has been made? We are assured, on excellent authority, that these tests would have been checked by experienced engineers, but they were never carried out because the company constantly withheld the opportunity of doing so. The reason put forth by the company was that the plant at Halifax was not completed. In the face of this, a matter extending over a period of six months, such invitations and facilities seem to be of but little avail.—Eds. Elec. Rev.]

The Heilmann Locomotive.

The letter of Mr. H. Ward Leonard deserves some reply—first, in regard to the analogy between a dynamo and turbine, in which he is entirely wrong. The analogy, so far as it applied to the Heilmann locomotive, is perfect, and is perfect, also, in other cases; of course, all turbines are not analogous to a dynamo, but some are, such as the inward flow type. There was a time, not so long ago, either, when some electricians did not know about counter E.M.F. in motors, and when they did find it out they did not, for a long time, know its functions. The same seems to be the case with turbines; it does not seem to be generally known that turbines can be designed, and are actually at work, in which counter centrifugal force comes into play and performs the same part as counter E.M.F. in dynamos used as motors.

If Mr. Leonard claims the varying of the volts as the speed desired, and the current as the torque required, and using a constant full excited field in the motors as his method, I am afraid he will find he is anticipated; that method has been used in battery cars where the field can be excited fully and constantly by the batteries, and the volts and current varied in the armature by a combination switch coupling up parallel and series arrangements.

For alternating current work, the transformer will do all that is necessary in varying volts and ampères.

Mr. Leonard's invention consists of a new combination for carrying out an old method of working, and no doubt has some field of application where it will be of great utility; but the *all*-sweeping claims made for this combination will never be realised in practice; at any rate, it would be wise to moderate them somewhat until actual experience proves their justification.

It takes some power to start a locomotive on any method whatever, and, "in the worst possible case," even with Mr. Leonard's combination, the load curve could not become so smooth as he claims.

For long distance railway work, the losses at starting are of no importance, as the number of starts made per mile, or per 100 miles, even, are few; "the vary the volts as the speed required, &c.," rule, does not apply with any force here.

For alternating current work, it may be remarked that

the whole argument in favour of the adoption of alternating currents in any case is, that you get rid entirely of such methods and combinations as Mr. Leonard's, and do everything with the simple transformer and commutatorless motor.

I readily admit that Mr. Leonard's combination is a genuine improvement, and that it would greatly reduce the energy wasted in motors running at variable speeds, and especially saving the power usually dissipated in resistances, and some few of the claims set up for the invention are not any too sanguine.

The Writer of the Article.

Country House Lighting.

I have read with much interest, in your last issue, the paper on "Country House Electric Lighting," by Mr. S. A. Court, and I beg to be permitted through your valuable medium to point out to this gentleman, that though he is in every way correct in his statements regarding Messrs. Carwardine & Co.'s installation, he has evidently been misinformed as to the conditions under which the same has been carried out.

It was I, with my assistant, Mr. R. A. Marples, who proposed this installation to Mr. Carwardine, designed same, erected it, and watched most carefully its running.

Permit me, therefore, to point out that:

Firstly, the windmill was not taken down because it was not a success; it was due to the fact that Mr. Carwardine was confronted with four separate legal actions, all of which he fought, winning three out of four, but unfortunately the fourth action was one which compelled him to take down his mill. The first-named action was by the London County Council, who claimed that the mill was a sky sign; the second, by his left-hand neighbour, who said that his mill-tail trespassed when the wind set the mill at right angles to the front of his building; the third, by his neighbour on his right, who said that the mill caused the smoke to go down his chimney; and the fourth, by the ground landlords, who claimed the mill to be unsightly, and dangerous to the neighbourhood.

As regards the fault Mr. S. A Court points out. At the time this installation was put in, there were not 27 16-C.P. lamps and three 12-ampère arc lamps, as stated. Mr. Carwardine merely asked for two 8-ampère arc lamps, and it was only when he was compelled to do away with his windmill, that he entertained the advisability of lighting the whole of his premises, and asked me to make use of the existing accumulators in the best way possible; the result being that the original dynamo and accumulators were left in and worked parallel.

In conclusion, I would add that it is most gratifying to me to find that Mr. S. A. Court, who has evidently most carefully investigated this windmill matter, and is doubtless an authority upon the subject, has only been able to criticise favourably the arrangement which caused me considerable thought at the time I installed same.

Arthur Bergtheil, M.Inst.E.E.

P.S.—It might be interesting to your correspondent to read the newspaper reports of the time of the installation, and I should be most happy to lend him same if he desires.

Manganin.

As the sole agents for the sale of Manganin in this country, we are naturally interested in Sir David Salomons's communication to you, with regard to the magnetic properties (?) of manganin.

Since reading his communication we have made numerous experiments, taking a perfectly new file and a heavy bar of manganin, producing considerable quantities of fine filings, but with the result that in all our tests there was a complete absence of magnetism.

It has occurred to us that possibly the sample experimented on by Sir David Salomons might have been exceptionally hard, as manganin under certain conditions is, and in such a state it might have removed particles of steel from the file itself, which would account for Sir David Salomons's observations.

Walter T. Glov & Co.

Shropshire Electric Light Company.

We understand that a report appeared in the issue of your paper of the 20th instant that the contract for the installation of the light had been given to Messrs. Edmundsons.

We must request that you will be good enough to at once contradict this report, as no arrangements whatever have yet been made in any way.

We act for the company.

Peele & Peele.

[We find on enquiry that the contract has not yet been given out.—Eds. Elec. Rev.]

Electricity Meters.

I trust you will allow me to point out that in the report of my paper on "Electricity Meters," published in your issue of April 20th, the position of the sheets in the proof appears to have become disarranged, as No. 3 follows No. 1, and I am reported to have stated that in Wright's maximum demand meter the principal difficulty is in keeping the clocks synchronous; and further, that the Thomson-Houston primary meter consists of a U-shaped tube, filled with a suitable liquid. These errors are, of course, very obvious; but at the same time the paper would have read so much more smoothly if the paragraph dealing with the difficulty of synchronising Aron meters, down to the end of the description of the Thomson-Houston primary meter, had been inserted before the description of the Schallenberger meter.

Further, I am reported to have said that a meter on the principle of Ferranti's mercury bath was designed and exhibited by Lord Kelvin. As a matter of fact this is not the case, and I corrected myself while reading the paper. A meter on this principle was first designed in 1883 by Mr. Ferranti, and another of his patents covers the principle of partially floating the fan immersed in the mercury bath.

Thanking you for inserting these corrections,

R. P. Wilson.

We notice in the report of the discussion on Mr. R. P. Wilson's paper on "Electricity Meters," which appeared in your issue of the 20th inst., that Mr. Madgen stated that the resistance of the shunt of the Thomson meter was 1,000 ohms. We should be glad to point out that at the present time this resistance is 3,000 ohms, except in the very large sizes, in which it is 2,000 ohms. The consumption, therefore, in the shunt is so small a percentage of the total amount of energy passing through even the smallest meters, that it is altogether negligible in view of the fact that energy generated in the station and utilised to overcome the initial friction of the meters is not more lost, and costs, if anything, less to produce than the energy which is not registered in meters whose initial friction is not overcome by a shunt.

We shall be much obliged if you will find space for the insertion of this letter, to avoid the possibility of a wrong impression being left in the minds of your readers.

The Laing, Wharton & Down Construction Syndicate, Limited,

James Devonshire.

Allow me to correct Mr. R. P. Wilson on a statement which he went out of his way to make in his paper on this subject at the Northern Society of Electrical Engineers. He says that the use of a step-down transformer to reduce the pressure in a known ratio on a measuring coil or instrument was originally used by Prof. Elihu Thomson in 1888. That may be so; but if he refers to a British patent list, he will find that I patented the combination in 1886, and used it in my original transformer investigations in 1885 on voltmeters and wattmeters. The combination has been discovered and claimed by more than one professor since 1886; but my patent remains the first evidence of its earliest discovery up to date. In making statements of this kind, the authors of papers should first make sure of the correctness of their historical knowledge.

Rankin Kennedy.

LEGAL.

Alabaster and Others *v.* Harness and Others.

In the Queen's Bench Division of the High Court of Justice, on Monday, Mr. Justice Hawkins, sitting with a special jury, had before him the case of Alabaster *v.* Harness.

Mr. Lawson Walton, Q.C., M.P., and Mr. Bankes appeared for the plaintiffs, and Mr. Jelf, Q.C., and Mr. Dodd for the defendant.

Mr. Walton, in opening the case, said that the plaintiffs were the proprietors of the Electrical Review, and they brought this action against the defendant, who was the managing director of the Medical Battery Company, Limited, to recover the costs of an action which had been brought against them by Dr. Tibbits. The allegation was that the defendant had instigated Dr. Tibbits, without reasonable or probable cause, to bring this action; that he had unlawfully maintained the same, and that in consequence of Tibbits being unable to pay the costs, they had been put to considerable loss. The case was one arising out of a series of articles which had appeared in the Electrical Review with respect to the business of which the defendant was managing director, and which had been prominently before the courts on a number of occasions. The plaintiffs had thought it their duty to warn the public against what they conceived to be impositions on the part of the Medical Battery Company in offering and selling electrical belts, which the plaintiffs endeavoured to show were absolutely worthless. As a result of one of these articles, the defendant had caused to be sent out to nearly the whole of the newsagents in London a circular threatening proceedings if the sale of the Electrical Review containing these articles were continued. Upon this coming to the knowledge of the plaintiffs a writ was at once issued against the defendant, claiming an injunction to restrain the publication of this circular, and for damages, the sale of the Review having been much affected. On September 23rd, 1892, there appeared in the Review an article headed "Electricity and the Medical Profession," which commented in somewhat severe terms upon a pamphlet which had been written by Dr. Tibbits with relation to Harness's electrical belts. Dr. Tibbits thereupon brought an action for libel against the present plaintiffs, and he thought in the course of the case it would be pretty clearly shown that these proceedings were commenced at the instigation of the defendant for the sole purpose of prejudicing the plaintiffs in other litigation which was pending with reference to the same matters. The action was tried, and in the result a verdict was given for the defendants. In the course of the trial it was elicited that Dr. Tibbits had no money of his own, and that the funds necessary in bringing the action were provided by the defendant Harness. As a matter of fact, of the costs—which when taxed amounted to £435—not a penny had been received from Dr. Tibbits.

Mr. T. E. Gatehouse, part proprietor of the Electrical Review, was then called, and bore out the opening statement of counsel. In cross-examination, he stated that there had been started an Electrical Review and *Science Siftings* defence fund, the object being to refund to the respective proprietors the expense they had been put to in the litigation between them and the Medical Battery Company. They, had, however, declined to receive any part of this fund, and he believed the money was returned to the subscribers. The Electrical Review had been making war upon the Harness electric belt since 1888. It was not done in a vindictive spirit, but in the interests of the public, whom they considered were being imposed upon by a worthless article.

Oliver Stockman stated that he was formerly a clerk in the employment of Mr. Fleet, who had acted as solicitor to the defendant and the Medical Battery Company. The witness was questioned as to what took place before Dr. Tibbits brought his action.

Mr. Jelf contended that the witness was bound to secrecy in all cases where his employer was bound.

Mr. Bankes said that maintenance was a criminal offence, and no privilege could attach to conversations with which it was planned.

Mr. Justice Hawkins said he would admit the evidence at plaintiffs' risk.

Witness, further questioned, said there were interviews at Mr. Fleet's office when the action was pending, at which Mr. Harness was present. It was arranged that Mr. Cridland, the solicitor to Dr. Tibbits, should prepare a writ, and submit it to Mr. Harness. Witness had discussed the action with the defendant, who, on seeing the pleadings, said they were not long enough. When he took the bill of costs to Mr. Harness, that gentleman complained of the amount, and suggested a smaller sum. Ultimately, on proceedings being threatened, the amount was paid.

Mr. John Frederick Spencer Cridland said he had acted as solicitor to Dr. Tibbits. He supposed that Dr. Tibbits was introduced to him for the purpose of bringing his action by Mr. Harness or the Medical Battery Company. The papers in the case were, he believed, submitted to Mr. Fleet. Before the action was brought he had no communication with the defendant or with the Medical Battery Company, although his clerk might have made some arrangement.

Upon this evidence Mr. Jelf submitted that there was obviously a common interest between the defendant and Tibbits in the action which had been brought, and the plaintiffs could not, therefore, succeed.

After further discussion it was agreed that the jury should be discharged, and the case adjourned for further consideration on the points of law arising on the argument of common interests.

Wise *v.* Metropolitan Electric Supply Company, Limited.

This case, which was adjourned a month ago, came on again for hearing before Mr. Justice Stirling on Wednesday. It is an action for an injunction against the continuance of the station of the defendant company in South Mews, Manchester Street, W., on account of the vibration, noise, and smoke proceeding therefrom.

Mr. Graham Hastings, Q.C., and Mr. Beaumont appeared for the plaintiffs, and Sir Richard Webster, Q.C., Mr. Phipson Beale, Q.C., and Mr. Vernon Smith for the defendants.

Sir Richard Webster said he had at the former hearing practically concluded his opening, but his Lordship would understand that when the case came to be finally considered, he might have some further matter to bring forward on the Electric Lighting Act itself. He was aware that there had been a decision upon a similar case since this case was adjourned, and he presumed that that might possibly, to a certain extent, affect the action his Lordship would take.

Mr. Justice Stirling: I understand the same point has been before Mr. Justice Kekewich, but I have not seen his judgment.

Sir Richard Webster said Mr. Justice Kekewich held that the liability to nuisance existed, but would not grant an injunction in the circumstances, and the plaintiffs were limited to their claim for damages. He had a very strong case for no injunction, and he desired to put forward all the evidence that would affect that question. But he was prepared to argue on the main part of the case, the legal aspect, if his Lordship thought proper, independently of Mr. Justice Kekewich's decision.

Mr. Justice Stirling: Unless you can in some way distinguish the legal point in this case from that Mr. Justice Kekewich decided, I shall follow his decision. But all that would be binding upon me would be his construction on the Acts and the order. I understand he dealt with that. As regards the application of the law to the particular circumstances of the case, that is another matter.

Sir Richard Webster said he desired to call his Lordship's particular attention to that part of Mr. Justice Kekewich's judgment which had reference to the injunction. In that regard the judge's finding was in favour of the defendants' case in this action; in fact, this case was a much stronger one on that point. There was an allegation faintly indicated by Mr. Hastings of negligence in the fact that they did not choose the best site. He would call evidence upon that point at once.

Mr. Stephen Babbington Barlow, of the firm of Barlow and Jones, solicitors to the defendant company, spoke of a conversation he had with Mr. Hunt, representative of Lord Portman, on June 1st, 1892. He made notes of what was said at the time, and had them before him now. Mr. Hunt spoke of South Mews as the best site to be found for the purpose of the central station between Oxford Street and Marylebone Road; it had been occupied, he said, by a filthy mews, and was at the back of small and old property. Mr. Hunt did not make the slightest suggestion that he did not approve of the site, nor did he raise any objection to the assigning of the lease by Mr. White, the previous holder, to the company.

Mr. Frank Bailey, engineer to the company since October 1st, 1889, said he supervised the construction of the station in Manchester Street with a view to the proper running of the engines, and was present at a number of interviews at which the question of possible vibration was carefully considered. The foundations at first consisted of a brick bed set in cement and resting upon a layer of felt, which in turn was placed upon sheet lead, whilst underneath that again were two or three feet of concrete. The foundations were perfectly isolated from the surrounding walls. The first complaints of which he heard were from the houses on the east side of the station, and those houses were eventually acquired by the company, who wired them for electric lighting and let them; the new tenants had never complained so far as he knew. Witness took three rooms at another house in the same street, and resided there for over a month at a time when four engines were running, and he never detected the slightest vibration. The houses in the street were pretty well kept, but were decidedly not well built. After complaints of vibration were received they carefully examined all the steam pipe connections in the station, and made every provision they could think of to isolate all portions of the moving plant from the surrounding walls. The exhaust pipe connection was cut off at the point where it left the engine, and the joint was made good with a copper sleeve. It was suggested that the exhaust of the vapour from the top of the shaft set up pulsations in the surrounding atmosphere, and to counteract any trouble from that cause they applied a fan, which blew air under pressure into the base of the exhaust pipe. He did not find any difference as the result of this, and came to the conclusion that no part of the trouble arose from that source. Another thing which was done in order, if possible, to reduce the tendency to vibration, was to reduce the speed of the exciting engines to the extent of 20 per cent. In 1892 complaints were received from houses on the west side of Manchester Street: at first he could not credit that there was the slightest cause for complaint, but after several visits to some of the houses, he did observe a slight tremor at No. 43. He reported the matter to his board, and was instructed to do everything possible to remedy it. He thought the explanation of the vibration was to be found in the presence of some sensitive communicating medium in the subsoil, and consequently sank a bore hole to a depth of about 45 feet or 50 feet. The first 25 feet consisted of a soft spongy clay, which was more like mud than anything else; below that was a bed of claystone, and below the stone a very hard dry blue clay. He thus found that the foundations of their engines rested upon a compressible bed, which was sufficient to account for the transmission of vibration. He submitted plans for sinking pillars or columns down to the hard clay, and bracing the tops of the columns by a system of girders, which would form a platform upon which the engines would rest. These plans were adopted and the columns sunk. Tests were made which revealed that there was no possibility of vibration being transmitted through the hard clay at the bottom. Quite recently it had been found that there was a slight lateral vibration, and to obviate it they decided to put in two diagonal struts, to the same depth as the vertical columns, and to tie them together

at the top where they joined the engine foundations. One set of these had been completed and sunk at the south end of the engine house, and it was intended to put in another pair of struts or raking piles at the north end. He was now making experiments with the view of reducing the noise, but he had not succeeded in ascertaining what were the best means to adopt.

Cross-examined by Mr. Graham Hastings, Witness said he did not assert that the vibration was completely cured yet, but when the raking piles were completed, in a couple of months' time, he thought it would be. If it were not, then the company was prepared to excavate all the spongy clay, which was the real cause of the trouble.

The Court then rose for the day.

Yesterday (Thursday) morning Mr. Beaumont took up the cross-examination of Mr. Frank Bailey, who said the vibration laterally at the engine beds would not be more than 2 millimetres, or $\frac{1}{32}$nd of an inch. There was very little difference in the effectiveness of a horizontal strut and one placed at 60° from the horizontal, in allaying lateral vibration; it was to be borne in mind that there were two struts placed at angles of 30° from the vertical, and an angle of 60° to each other, and these were embedded in the hard clay at their bases, and tied together at the apex of the triangle. Speaking of the vibration at Wise's house, diagrams showing which were put in, he said the variation in the length of these vibrations was caused by the variation in the speeds of the engines at the station. He thought the evidence of plaintiff's witnesses was slightly coloured as to the vibration; he would not say it was inaccurate or exaggerated. Prof. Thompson used "artistic colouration," and perhaps saw and experienced more than witness did. Cracks showed themselves in the chimney in the latter part of the summer of 1891, and he advised hooping, but came to no conclusion as to the cause of those cracks. To remove the mass of spongy clay and fill up the space with concrete would not be a very difficult matter; it was merely a question of time and expense. If it became necessary to substantially reduce the lighting from the Manchester Street station, it would be possible to supply some part of the district from the Paddington station, but not the whole, without removing a large proportion of their machinery, and really putting in a special type of machine. Nothing was really impossible; it was all a question of expense. The company at one time intended to put slow speed engines in in place of the present fast speed ones, and he tried to get alternators made to suit the altered conditions, but did not succeed in getting them.

Prof. A. B. W. Kennedy gave evidence as to visiting several of the houses in which it was alleged vibration caused annoyance. In some cases there was slight vibration, but very slight, and in others no vibration at all could be detected, He expressed entire approval of the steps taken at the works to prevent vibration.

After hearing further evidence, the Court adjourned for the day.

(To be continued.)

AUSTRALASIAN ELECTRICAL NEWS.

[From our own correspondent.]

The Launceston electric lighting affair has not yet come to a satisfactory settlement, and Alderman Barrett of the Launceston City Council, a fortnight ago, gave notice that he would move at the Council meeting, to be held last Monday, the following resolution:—That in the event of the committee appointed to consider and report upon the tenders for electric lighting of the city failing to bring up a report on or before Monday, March 12th next, the said committee be discontinued, and that the tender of the Henley Company be accepted, for the following reasons:—1. The Henley Company's tender is the lowest by the large sum of £4,800, which, with the superintending engineer's commission of 5 per cent. would effect a saving of £5,200, or upwards of 16 per cent. below the tender recommended by Mr. K. L. Murray. 2. The Henley Company, as contractors to all the principal electric supply companies throughout the world, have established a world-wide reputation financially and professionally, and, therefore, would undoubtedly carry out the contract to the entire satisfaction of the Council's superintending engineer, under whose control the whole of the works of the contract, as stipulated in the conditions, are absolutely placed. 3. The Henley Company manufacture their own electric cables, which constitute one-third of the entire value of the contract; and, as the whole of the plant would be that of the celebrated Brush Company's manufacture, the combination is similar in every respect as in the City of London, where the Henley Company supply the cables, and the Brush Company the plant.

However, on Monday, the Electric Lighting Committee presented their report, recommending that Messrs. Siemens Bros. tender be accepted; and the council have recommended the adoption of the report, three of the councillors dissenting.

On March 8th, the Melbourne Municipal Electric Light Station was formally opened. In the lighting of the streets, 633 arc lamps of 1,200 (nominal) candle-power, and 1,200 32-candle-power incandescent lamps are employed. The plant is divided into four sections, three of which are sufficient to do all the work, the fourth being in reserve. Each section consists of a 300 horse-power compound condensing engine, made by the Austral Otis Company, running at 32 revolutions and driving 30 feet of 6 inch counter shaft at 200 revolutions, to which are connected five 50-light Thomson-Houston arc dynamos, with provision for a 1,000 light incandescent dynamo. Each section is supplied with steam by a Babcock and Wilcox boiler, of 250 horse-power, giving steam at 150 lbs. pressure. Water is supplied from the River Yarra, by means of a compound direct-acting duplex Worthington pump, capable of delivering 40,000 gallons per hour, the feed water being forced through an economiser, raising it to a temperature of 270°. The arcs and incandescent are run in series, the arcs being placed in the centre of the streets where permissible, all wiring at present being overhead. Complaints have been made with regard to telephone interference, some lines being said to be quite unworkable during lighting hours. This station is referred to in our Business Notes.

Last week, a deputation, representing the electric light companies of Melbourne, waited on the Acting Post-Master General to urge that no further time should be lost in getting the Electric Lighting Bill passed by Parliament. It was contended that as the companies had spent something like £200,000 in introducing electric light into private use in the city, their interests deserved consideration. The matter was postponed until the return of the Post-Master General, at present in New Zealand attending the Postal Conference.

The Melbourne municipal plant is estimated to have cost £75,000 to lay down, and the annual cost of running about £20,000, slightly less than the cost of gas for the past year, with an aggregate candle-power about 16 times that of the gas lamps.

BUSINESS NOTICES, &c.

Poplar and Electric Lighting.—Mr. W. H. Preece has recently reported upon the electric light for the district of Poplar, provisional orders in respect of a small area having been obtained some time ago. Mr. Preece commences his report with a few cogent observations upon the general advantages of public lighting by electricity; he also points out that the provisional order having been secured, the obligation of going on with the work is laid upon the board. The first question to be decided, he says, is whether the board shall itself provide the light, or whether their powers shall be transferred to a private company. He is not an advocate for inviting private enterprise to undertake such work, for numerous reasons. A private company means a greatly enlarged capital for the purpose, and that capital would not be wholly devoted to the legitimate object of lighting the district. It would also mean the necessity for a larger income to find the dividends, hence customers would pay more for their light, and the ratepayers be thus unnecessarily taxed. He instances several cases, especially that of the City of London, in support of this contention, and points out that St. Pancras, which itself supplies the light, does so at a less charge. Besides which, a local authority obtains capital at the cheapest rate, from 3 to 3½ per cent., and it expends all its money legitimately on the object to be attained. Mr. Preece says the population of the three parishes of Bow, Bromley, and Poplar, comprising the administrative area, is 166,000; the length of street is 60 miles, or 100,000 yards. The length of street comprised in the provisional order is about 6,000 yards, or 6 per cent. of the whole. Anyone in the compulsory area must be supplied with electricity on demand, and, provided certain conditions are fulfilled, anyone outside that area must also be supplied if needed. Hence it is necessary to consider the needs of the whole district, and the first provision of buildings, plant, and system of mains, must be devised with some elasticity, and be capable of extension easily and quickly. He estimates the ultimate demand in Poplar to be for 50,000 8-candle-power lamps: the installation of this number of lamps would cost £150,000, the annual income would be about £22,000 at 6d. per unit, and the profit, after all allowances for the reduction of debt and sinking fund, about £9,000, or 6 per cent. on the capital. But this demand would not occur for some years, and it would be sufficient to commence the work with a station sufficiently large to meet a demand of 10,000 lamps, but it would be necessary to provide a building of sufficient size to meet the ultimate demand mentioned. The plant could be increased as occasion required. The two streets that Mr. Preece considers the most worthy of the expense of lighting by arc lamps are the Bow Road and the East India Dock Road; 20 lamps would be required to light the former well, and 15 lamps the latter. Allowing for local conditions, he considered the 35 arc lamps in the two roads could be provided at a cost of £18 per lamp per annum. Therefore, the cost of that lighting would be about £630, against the present cost of £240 for gas lighting in the Bow Road and £140 in the East India Dock Road—a total of £380. The extra cost for electricity would, therefore, be £250; but, as the power of an arc lamp is at least 1,000 candles, the streets would be lighted by 35,000 candles against the present light of 2,400 candles. The capital outlay for the 10,000 8-candle-power glow lamps, with plant and lamp-posts, would be as follows:—Buildings, £6,000; machinery, £13,500; mains, £65,000; contingent and engineer's expenses, £2,500—total, £28,500. This estimate includes £1,200 for machinery and £1,000 for mains for the public street lighting. With £2,000 for the working capital, a total outlay of £30,000 would be required. For the first year the working expenses would be £3,890, and profit £140; for the second year, working expenses, £5,040, profit, £1,290. The site of the Animal Charcoal Works had been suggested as suitable for the buildings. As the compulsory areas are about 2,500 yards, the high pressure system would have to be adopted. Plant must be in duplicate so that no breakdown should occur in the public lighting.

Marryatt, Lillywhite & Co.—This firm have received instructions to instal a complete plant for about 200 16-C.P. lights for Mr. J. W. Kennedy at the "Horseshoe," Chatham. The same firm have just completed the lighting of Mr. Walter Hazell's house in Russell Square, and have at present installation work in hand at Manchester, Liverpool, Cardiff, Richmond, and London.

Electric Light at Melbourne.—On 8th ult. was started a portion of the electric lighting plant which has been erected by the City Council. The current was switched on by the Mayoress of Melbourne. The system adopted is the incandescent continuous current. The plant has been laid out in four sections, each complete in itself. Three sections are sufficient to light the whole of the city, the fourth being at all times a stand-by in case of any part of one section failing. A section consists of one 250 horse-power boiler, one 300 horse-power engine, one 30 feet length of shafting, and five 50-light arc dynamos. The connections from the 20 dynamos all run up to a main switchboard seven feet above the floor level, access to which is by a two-way staircase. The boilers are of the Babcock and Wilcox make, partially manufactured in the colony. They are fed by steam pumps of the direct-acting duplex type, of Worthington make. The suction pipe can be fed from three different sources: First, hot well; second, storage tank of 48,000 gallons underneath the coal bunkers; and the third from the Yan Yean direct. The engines were manufactured by the Austral Otis Engineering Company. They are compound surface condensing, and require a steam pressure of 150 lbs. per square inch. They work at a rate of 82 revolutions per minute, driving by ropes on to a 6-inch countershaft, which runs at a speed of 200 revolutions per minute. The water for condensing purposes is forced up from the Yarra by a compound duplex direct-acting pump, situated in the new Fish Market buildings. On each section of shafting five arc dynamos are coupled, fast and loose pulleys manufactured by the Langlands Foundry Company being used. The dynamos are of the Thomson-Houston make, imported from America, and specially adapted for running arc and incandescent lamps in series, being fitted with an automatic regulating gear to maintain a constant current. Two circuits are run along every street, each circuit taking every alternate lamp, so that in the event of the failure of one circuit, every alternate lamp will still be alight. The nominal candle-power of the arc lamps is 1,200, and the actual candle-power of the incandescent 32. The arc lamps have been erected on special cast-iron pillars, with wood extension pieces. In the main streets where the tram lines exist, great difficulty arose in placing the pillars owing to the existence on one side of the telephone wires. This has necessitated the erection of many wooden poles, which to some extent obstruct the light; but with the substitution of the underground system, which is being contemplated for the main streets, these poles will all be removed to the outlying districts. The electric lighting scheme having been approved by the Council, the money required for the work was provided for in the City Corporation loan of £125,000, floated in 1892. The public lighting section of the scheme will cost, when completed, £75,000, so that there will be then £50,000 available for private lighting purposes.

Dock Lighting.—At the recent monthly meeting of the Leith Dock Commission. A letter was read from the Superintendent regarding the arrangements for the introduction of the electric light in the docks. Mr. Chalmers said the board had decided to delay introducing electricity until the city of Edinburgh had introduced it, so that they might avoid any rocks that Edinburgh might stumble upon, and they could have the benefit of the experience to be learned by Edinburgh in introducing the light. Mr. Cormack said the electric light applied only to the Old Dock and the Victoria Dock. He considered that the Edinburgh Dock and the Albert Dock were quite as important, and certainly more so than the Old Dock. Mr. Weir said they had resolved to proceed with the installation at the Old Dock and the Victoria Dock first, because they were going to enlarge the docks on the other side. That was an experimental installation, and the other would be carried out when the new docks were built. Mr. Cormack said the lighting of the Edinburgh Dock at the back of the sheds was shocking. If they did not go in for electric lighting they must have gas, and that immediately. The Clerk, reading from a previous minute of the Board, said the cost of the electric light would be £3,000. There was no reference, he said, to delaying the introduction of the electric light until Edinburgh had introduced it. The matter was referred to the Works Committee, with powers to go on with the work they had agreed upon. It was also remitted to the same committee to see about the lighting in the Edinburgh Dock.

Self-Lubricating Bearing.—Efficient lubrication without waste of oil, being an important consideration wherever machinery is employed, especially in such establishments as electric light stations where economy has to be studied in every detail, various well-known arrangements have been devised for the continuous lubricating of bearings. The most recent novelty in this line, which is being introduced by Mr. W. Farrar, electrical engineer, of Harold Walk, Leeds, and Perseverance Works, Morley, is worthy the attention of dynamo builders and others. The principal point of novelty is the use of pieces of cane which are screwed into the bottom brass, and are immersed in oil contained in a box-shaped reservoir which forms a part of the bearing support. In operation the oil rises in the interstices of the cane and lubricates the shaft the surplus oil escaping at the ends of the brasses and returning to the reservoir. We may add that this lubricating arrangement has been thoroughly tested, having been run for months without requiring any attention whatever, keeping the shaft continuously in a bath of oil, and the oil remaining as clean as when put in. The saving of oil and labour, not to mention the prevention of heated bearings, is among the material advantages which appear to be justly claimed for this simple device. Leakage and consequent dropping of oil, which is characteristic of many continuous lubricating arrangements is avoided, and it is immaterial whether heavy or light-bodied oils are used.

Mavor & Coulson.—This firm have appointed Mr. H. T. Barnett, of the London Electrical Goods Agency, St. Margaret's Offices, 53, Victoria Street, S.W., as their agent for the London district.

Stafford Electric Lighting.—At a recent meeting of the Town Council the Electric Lighting Committee recommended the following tenders for acceptance:—For the electric works—engines, Messrs. Robey, £2,288; boilers, Hicks, Hargreaves & Co. (Bolton); dynamos, the Electric Construction Company (Wolverhampton), £1,151; buildings, Mr. J. Lovatt (Wolverhampton), £3,030; ironworks and roofs, Messrs. Rubery & Co. (Darlaston), £197. Alderman D. H. Peach, in proposing the adoption of the report, said that, owing to some misunderstanding about the tender of Messrs. Robey for the engines, it would be necessary to refer it back to the committee. Councillor H. H. Jordan moved, as an amendment, that the tender for the buildings should be given to Mr. F. Espley (Stafford), at the sum of £3,050. Councillor Bennett seconded. A long discussion took place on the matter, during which it was stated that originally Mr. Espley was recommended for the tender, but was subsequently withdrawn; and an explanation was asked for as to why this had been done. The chairman explained that the tender for the buildings was passed at the first meeting of the committee against his advice, and as it turned out afterwards, there was a misconception as to the quality of the bricks to be used, it was felt that the tender recommended by the committee was the best, in the interests of the ratepayers. On being put to the vote, thirteen voted for the amendment and seventeen against.

The Lighting of the Embankment.—In their report to the London County Council, the Highways Committee stated that they had considered the advisability of widening the footways of the Victoria Embankment by taking in a few feet of the carriageway on each side, in order to allow the electric light standards to be placed on the sides of the carriage-way without interfering with the trees. They pointed out that the footways were of great width—20 feet on the river side, and 16 feet on the other—and in order that the lamp standards might be clear of the trees the width of each of the footways would have to be increased by 8 feet, and that of the carriageway correspondingly reduced from 64 feet to 48 feet. Having regard to all the circumstances, they were of opinion that it was not advisable to widen the footways. They understood that the Parks Committee had now under consideration a suggestion that some of the trees should be removed to facilitate the proper growth of the remainder; and they thought it advisable that until some decision should have been come to upon this suggestion, the further consideration of the question of the positions to be occupied by the lamp standards, should be deferred.

Sunderland Electric Lighting.—A special meeting of the Highway's Committee of the Corporation was held last Friday for the purpose of considering the progress of the preparations for lighting the principal streets of the town by electricity, and the question of the contract to be made with the gas company in view of those preparations. The Borough Engineer gave it as his opinion that all would be ready for commencing electric illumination next December. The present contract with the gas company expires in June. The number of gas lamps in the area to be lighted by electricity is 92, eight of which are large Sugg lamps. The Committee decided to negotiate with the gas company for the purpose of entering into another contract for one, two, or three years, with power to withdraw all or any of the lamps in the electrically lighted area, and that in the meantime Prof. Kennedy be requested to prepare an estimate of the number of lamps required, their cost, and the cost of supplying them with electricity for street lighting.

Improvement of Incandescent Lamps.—An excellent method of coating the bulbs of incandescent lamps has been invented and patented by Mr. N. Fabris, of 171, Drummond Street, Hampstead Road, London. A lamp with the bulb ground in the ordinary way gives considerably less light than with the glass clear, but if coated with this composition, the amount of light has the appearance of being increased, owing to the way in which it is concentrated and improved in colour. Coated with this composition the lamp has a pleasing appearance, the filament being invisible, and there is no need for any other kind of shade or reflector. Another advantage is that the application of the composition to a lamp strengthens the fixing of the bulb to the brass rim of the lamp, thus preventing the fragment breakage of lamps which is consequent on the bulbs becoming disconnected from the part supporting the filament. The larger the lamp used, the greater is the advantage gained by the use of the "Snowflake" composition.

Mill Lighting.—Messrs. J. H. Holmes & Co., of Newcastle-on-Tyne, have completed a large lighting installation at the Stockport Ring Spinning Company's Mill, Stockport. The mill is lighted by 800 16-C.P. incandescent lamps, and 4 200-C.P. lamps have been fixed outside. The current is generated by a "Castle" dynamo of 850 lights capacity, driven from the mill shafting through a friction clutch. There is also a pilot dynamo for 350 lamps driven by an independent engine and supplying current to three pilot circuits which light up the engine and boiler houses, offices, staircases and passages, and about one-third of the lamps in each of the other rooms.

Dartford and Electric Lighting.—At a recent meeting of the Local Board it was stated that the Electric Construction Company wrote that they noticed a member of the Board was preparing a scheme to light the town by electricity, and they would be glad for a deputation to visit their works at Wolverhampton to see their system which was being used at Halifax, Burnley, Dudley, and other big towns. It was decided that the Board were not prepared to consider the question, having entered into a three years' gas contract.

Ship Lighting.—The Great Eastern Railway Company on Saturday last launched a new steamer, the *Berlin*, from Parkston Quay, Harwich. The vessel is lighted throughout by electricity.

Dublin Electric Lighting.—At a recent meeting of the Corporation Mr. Robinson moved the adoption of the report of the Electric Lighting Committee, which recommended the acceptance of the tender of Messrs. Fowler & Co. for £8,050 for the entire work regarding the extension of electric plant, be adopted, the conditions being that the buildings be executed by Dublin tradesmen at the standard rate of wages paid in the district, and that the boilers, and copper steam and exhaust pipes be manufactured in Dublin. He said that their customers were increasing every day, and that during the past quarter they received £1,700 in advance of the same quarter last year. Alderman Flanagan seconded the motion, which was carried.

Tenders for Wiring St. Bride Institute.—The following is a list of the tenders sent in for the wiring of the St. Bride Institute. The number of lights is about 250:—

Messrs. Strode & Co.	£717
Messrs. Rashleigh Phipps & Co.	708
Messrs. Crompton & Co., Limited	707
Messrs. The Planet Electrical Engineering Company	668
Messrs. Edmundsons	615
Mr. A. H. Wood, 39, Victoria Street, S.W.	563
Messrs. Laing, Wharton & Down	509

Underground Mains.—The underground work for the Edinburgh Corporation electric light scheme is now in progress. The Doulton casing is being used, and about fifty miles of 2½ inch "ways" on this system will be laid. The Sunderland conduits will, we understand, shortly be commenced, and for this work about 10 miles of 2½ inch "ways" of Doulton casing will be provided for the reception of the cables. Some bare copper mains in culverts will be laid both at Edinburgh and Sunderland, and special insulators for both contracts are being supplied by Messrs. Doulton & Co., of Lambeth.

Hotel Lighting at Hastings. — On Saturday last Messrs. Spiers & Pond formally opened the new Palace Hotel at Hastings. An electric light installation effects the lighting throughout the buildings. The proprietors have erected, at a very considerable outlay, their own installation, and for this purpose have placed the engines, dynamos, and storage appliances in large recesses, hollowed out of the cliff at the back of the premises. By this contrivance the vibration of the machinery is not felt in the residential portion of the hotel.

Drake & Gorham.—This firm has been entrusted with the lighting of Baron William von Schröder's country house at the Rookery, by means of a steam plant. The dynamo will be of the latest pattern, E.C.C. type, 135 volts by 90 ampères, to charge a 100-light D.P. battery. The firm are also arranging for telephones to be placed between the main building and engine house, which is some distance from the house. The number of lamps will be 200, of various candle-power.

Price Lists, &c.—Messrs. Faraday & Son have sent us a list of their reflecting standards for fixtures, &c.

From the Edison & Swan United Electric Light Company, Limited, we have received a large show list which illustrates a number of special new designs of electroliers, standards, brackets, pendants, hanging lamps, portable lamps and ceiling fixtures. There are some very artistic designs shown on this sheet.

Littlehampton and Electric Lighting.—Several persons having enquired of the Board as to their intentions regarding the supply of electricity in the district, the Board have replied that, although they do not contemplate supplying the electric light in their district at the present time, they would not oppose the formation of the company for the purpose, subject to the conditions being satisfactory to them.

Alleged Robbery.—At the Woolwich Police Court last week two labourers were charged, one with stealing and the other with receiving, from Victoria Works, Victoria Road, Charlton, 6 ingots of gun metal, 280 lbs. of copper wire, &c., value £13 11s., the property of Walter Claud Johnson (Messrs. Johnson & Phillips), electrical engineers, Victoria Road, Old Charlton. Prisoners were remanded.

Business Announcement.—The National Telephone Company having acquired the business of the Home Telephone Company, Mr. John L. Newland, who was manager of the latter company, has now assumed the management of the Private Wire and Telephone Installation Company, at 110, Cannon Street, E.C., who are prepared to carry out all kinds of telephonic and electric bell work.

Charing Cross and Euston Railway.—We hear that the company formed to make a connecting link and thoroughfare between Charing Cross and the Euston Road termini, has not gone to allotment. The prospectus will be revised, and the scheme will probably be put before the public again in a few months' time.

Morecambe Electric Lighting.—A deputation of owners of property in several streets waited upon the Local Board the other day to complain of the nuisance caused by the electric lighting works in Edward Street and Union Street. The nuisance complained of is vibration and bad smells.

Mill Lighting.—The Island Flour Mill, at Midsomer Norton, has been fitted up with the electric light. Mr. Charles H. Shearn was the engineer for carrying out the work.

Wrexham and the Electric Light.—The Wrexham Town Council have accepted the offer of the Wrexham Electric Lighting Company to sell their provisional order for the installation of electric lighting in Wrexham and district for the sum of £350.

Electric Light at the Agricultural Hall.—Messrs. Gent & Co., of Leicester, have secured the contract for lighting the offices or shops into which the centre of the hall has been divided, over 100 in number, also the stands and exhibits at the forthcoming Shoe and Leather Fair, Agricultural Hall, London.

Castleford Lighting.—Mr. Robert Hammond, who is preparing a scheme for lighting Castleford by electricity, has written explaining that he was delaying the completion of his plans, which contemplated the use of steam power, pending the results of visits to several places where gas is employed as the motive power.

Hermite Process.—Should any of our readers wish for copies of Dr. Piton's report on the "Hermite Process of Disinfection by Electrolysed Sea Water," they can obtain them from Messrs. E. and F. N. Spon, 125, Strand, price 6d.

Failure of the Electric Light at Norwich.—At a meeting of the Norwich Town Council last week, the electric light suddenly went out leaving the Council Chamber in darkness, and the gas had to be lighted.

Windsor and the Electric Light.—A petition is being signed throughout the town to the Town Council urging that body to take immediate steps to provide the town with electric light.

Electric Light at Baslow.—The question of lighting the establishment of the Baslow Hydropathic Company, Limited, with the electric light is under the consideration of the directors.

CONTRACTS OPEN.

Devon County Asylum, Exminster. — May 15th. The Committee of Visitors having decided to carry out, with their own staff, the wiring of this asylum, are prepared to receive samples and prices of the following materials:—1. (Per mile). Tinned and stranded copper wires from 3/22 S.W.G. to 19/14 S.W.G., insulated with pure and vulcanised rubbers, the insulation resistance of which shall not be less than 600 megohms per mile. 2. (Per pound). Pure rubber strip vulcanising rubbers, prepared tapes, and India-rubber solution. 3. (Per 1,000 feet). Best American whitewood casings and moulded covers, in various sizes, from 1½ inch to 4 inches in width. 4. (Per gross). Single light cut-outs, ceiling plates with wooden cord grips, quick-action make-and-break switches, holders and shade carriers, brackets and shades. Tenders marked "Electric Lighting Materials," should be sent in to Arthur E. Ward, of 9, Bedford Circus, Exeter, clerk to the said committee.

St. Pancras.—May 7th. For buildings to contain the electric lighting plant (engines, dynamos, boilers, &c.) to be carried out at the electric lighting and refuse destructor station, King's Road, Camden Town, N.W., for the St. Pancras Vestry. The drawings can be inspected, and copies of the specification, schedules of quantities, and general conditions can be obtained at the offices of Prof. Henry Robinson, C.E., 13, Victoria Street, Westminster, on payment of 10s. (which will not be returned.)

BOOK RECEIVED.

Magnetische Kreise deren Theorie und Anwendung. *Von* Dr. H. du Bois. Published by Julius Springer, Berlin.

FORTHCOMING EVENTS.

Friday, April 27th.—Physical Society, at 5 p.m. "The Mechanism of Electrical Conduction," by Dr. C. V. Burton. "A Graphic Method of Constructing the Curves of Current in Electro-magnets and Transformers," by Major Hippesley, R.E. "The Design and Winding of Alternate Current Electro-magnets," by Prof. S. P. Thompson, F.R.S.

Wednesday, May 2nd.—Institution of Civil Engineers, at 8, "The Relation of Mathematics to Engineering," by Dr. John Hopkinson, F.R.S.

Friday, May 4th.—Meeting of the Electrical Section of the London Chamber of Commerce at Botolph House, Eastcheap, E.C., at 2.30 p.m., to consider the Locomotive Acts in relation to the Traction Industry.

Friday, May 4th.—Institution of Electrical Engineers (students' meeting), at 28, Victoria Street, S.W., at 8 p.m. A paper will be read entitled "A Description of the Electrical Type-printing Instruments, as used by the Exchange Telegraph Company," by Mr. F. Digby-Latimer.

Friday, May 4th.—Old Students' Smoking Concert, to be held at Mason's Hall Tavern, Mason's Avenue, Basinghall Street. See our remarks under "Notes."

NOTES.

Electric Illumination.—Prof. Fleming concluded his series of Royal Institution lectures on "Electric Illumination" last Tuesday. The generation and distribution of electricity was the subject of the discourse. The audience were told a good deal about the effects of magnetism; then they were treated to a series of views of central stations, the Tivoli station being minutely described.

O.S.A. Smoking Concert.—On Friday evening, May 4th, the Old Students of the City and Guilds of London Institute will hold a Smoking Concert at Mason's Hall Tavern, Mason's Avenue, Basinghall Street. Mr. T. E. Gatehouse will fiddle, Mr. T. H. Harrison, Mr. Thos. Adams, and Mr. Arthur Melrose will sing, and other able performers, including Mr. Ed. C. de Segundo (piano), and Mr. Leo Taussig, a favourite pupil of Popper, an eminent instrumentalist (cello), have promised assistance, and as it is a considerable time since the last social meeting of this kind was held, we hope that the members of the O.S.A. will assemble in large numbers, and that their professors will also deign to grace the entertainment with their presence should their engagements permit.

Improvements in Electric Traction.—The battery locomotive or car for street railways has been tried in America, but no battery has been found equal to the work; they are two heavy, the capacity is too low, they are too fragile, and the efficiency is not over 50 per cent. These are the objections raised in practice to the use of storage batteries in traction, there is also the trouble in constantly handling the heavy battery. At every charging period the empties must be hauled out of the cars and the full cells put on; either that, or the one-half of the cars must stand idle while charging, hence the trolley holds the field in practice, even with its admitted inefficiencies. Many inventors are at work on the problems connected with traction, especially to improve the trolley system, the H. Ward Leonard system being one with that end in view, which promises well. We have given it special notice in our columns. We cannot but think that something to reduce the objections to battery cars could be devised, hence we heartily welcome any improvements in batteries with that end in view.

Annual Sittings of the French Physical Society.—Every year, at Easter, the French Physical Society holds an exhibition of all the new or interesting apparatus that have come into public notice during the year. This exhibition was, this year, held during two days on the premises of the Société d'Encouragement, Rue de Rennes, Paris. The electric lighting of the halls was effected from the local works of the Society, which contain a compressed air motor, supplied by the Parisian Compressed Air Company, and a Gramme machine. There were 12 Cance lamps, of 8 ampères and 70 volts. In the entrance hall the arc lamps were furnished with holophanous globes, of the Psaroudaki and Blondel type. According to the inventors, these globes diffuse the light more advantageously for purposes of illumination than the ordinary globes, and the luminous efficiency is increased 30 per cent. We will only discuss here the electrical exhibits. We may, however, mention first the de Laval turbine. Mr. Aylmer exhibits several models of Lord Kelvin's multicellular voltmeters and aperiodic ampèremeters. M. Bonetti showed several electrostatic machines, without sectors, and with multiple brushes. The firm of J. Carpentier, contributed several measuring instruments, and also some photographic apparatus. Messrs. E. Ducretet & Lejeune, exhibited a Wimshurst machine, some Wheatstone bridges, a rotatory commutator transforming continuous currents into triphased currents with a revolving field electric motor, and a portable apparatus for rapidly measuring the insulation of conductors up to 80 megohms. M. J. Richard showed a little balanced pocket voltmeter, with armoured magnet for testing batteries and accumulators. M. Pellat exhibited a little working model of an apparatus registering the speed of trains, and a system of signals calculated to prevent collisions, and M. Werlein showed a standard arc, with horizontal carbons by M. Blondel. On Thursday, March 29th, the members of the French Physical Society paid a visit to the works of the Northern Tramways Company (Paris). Electric traction by accumulators is employed by this company.

Lectures.—Before the Royal Scottish Society of Arts, on Monday last, Mr. Thomas Edmonston read a paper on "Direct Current Dynamos and Motors: Their Magnetic and Electric Currents."

Quick Work.—The following information sent to us by Mr. G. Kenyon, electrician at the West Hallam Collieries, may be interesting to "armature winders" and electricians-in-charge, as well as being a record:—On Friday last the armature of one of the "motors" in use at the West Hallam Collieries burnt out; luckily it happened just as the pit was about to close for the day. Not having a spare armature at the place the situation looked rather grave for Monday's working, as there had to be hauled about 600 tons a day with it. The armature was removed and unwound. The electrician had to send at least a distance of 120 miles for materials with which to rewind. These arrived at 4 p.m. on the Saturday. The work of rewinding was started at 7 p.m. on Saturday night, and all completed with commutator and binding straps on and the motor was running again by 2.30 a.m. Monday, after the lapse of 31½ hours, time being allowed for meals. The armature is drum wound, has 84 sections, and takes 494 yards of wire No. 7/18's.

The Currents in a Primary and Secondary Coil.—In the *Philosophical Magazine* for April, there is a short paper by Prof. G. M. Minchin, which contains a solution of the following problem:—A primary and a secondary coil occupy given positions; an alternating electromotive force, expressed by a sine function of the time, being applied to the primary, it is required to represent graphically the impedances and phases of the primary and secondary currents for all speeds of alternation. (No iron cores are employed.) In solving this problem Prof. Minchin adopts the notation used by Mr. Rimington in a paper read before the Physical Society on October 27th, 1893, in which the same subject was presented in a different manner. The argument is purely mathematical, and is not susceptible of condensation or abstract. We must therefore refer our readers to the original paper, which will prove an extremely useful exercise on a subject concerning which practising engineers cannot know too much.

A Big Electric Railway Scheme in New Jersey.—A despatch from Trenton, New Jersey, dated 13th inst., states: "There was filed in the office of the Secretary of State to-day an article of incorporation for the Central Jersey Traction Company, which is to develop the electrical scheme devised by Joseph H. Realls, of New York, who expects to connect New York and Philadelphia, and all the intermediate points, by trolley. It is to touch Orange, Irvington, Bloomfield, Elizabeth, Newark, Rahway, New Brunswick, Plainfield, Bound Brook, Princeton, Lawrenceville and Trenton, then will cross the river and join the electric line, developing there into Philadelphia. The incorporators are J. H. Baldwin (Orange), John H. Tingely (Rahway), and George G. Crosby (New York). The capital stock is $150,000, with power to increase to $10,000,000. This road is to be operated independently of the New Jersey Consolidated Road, but not in opposition, claiming friendly relations."

Ball Lightning.—An instance of this rare phenomenon is described in the *Zeitschrift für Elektrotechnik*, xii., 73, as having occurred at the Imperial Post Office at Oderberg, in Prussia. During a severe thunderstorm, a telegraph pole about 500 metres from the post office appears to have been struck by lightning. At the same moment three persons employed in the post office, standing round one of the tables, saw, as if between them, some 20 centimetres above the table, a blindingly bright fiery ball about the size of a fist, which immediately exploded with a loud report without injury to anybody. One of the spectators says that he observed that the ball of fire came down from above on to the table, then rebounded and exploded at the height already stated. The table in question stood a little to the right, and beneath the lead-coated cables which passed tranversely across the middle of the post office to the batteries. A fiery discharge was seen to pass from the cables to a petroleum lamp suspended on a metal hook at a distance of 20 centimetres on the other side of the cables from the table.

Correction.—On page 467 of the number of the Review for April 20th, it is stated, with reference to Prof. Ayrton's paper on "An Astatic Station Voltmeter," that "a bit of the scale *full size* is seen in fig. 4;" the actual fig. as shown is, however, considerably reduced in size from the original. As the boldness of the scale is a very important feature in the instrument, for it enables the engine driver to see the reading from the opposite side of the engine room, the reduction requires to be noticed.

Coast Communication.—In the annual report of the National Lifeboat Institution for 1893, the following paragraph appears:—

The important system of electrical communication on the coast for life-saving purposes, commenced by the Government in 1892, was considerably developed last year, and it was hoped that the line of communication would, before another year was over, have been extended to all the more dangerous parts of the British coast. Steps had been taken to give effect to the recommendations of the Royal Commission as regarded connecting the rock lighthouses and light vessels with the shore.

Electric Athletic Association.—Holborn Town Hall was last Friday the scene of a very successful social gathering, held under the auspices of this association, which exists for the physical benefit of both sexes engaged in the work of the central telegraph office. A large company was received by Mr. H. C. Fischer (Controller of the Telegraph Department, and President of the Association), and Mrs. Fischer, among those present being Mr. Spencer Walpole, Mr. J. C. Lamb, Mr. W. H. Preece, C.B., F.R.S., Mr. E. May, and Mr. J. Hookey.

German Telegraphs.—In 1892 the German telegraph system had a total line length of 102,118 kilometres, of which 5,961 was underground and 2,933 submarine. The total wire length was 372,175 kilometres. There were 12,438 State offices open and 3,703 railway offices. The staff consisted of 7,976 persons. The number of instruments: 11,510 Morse, 436 Hughes, 10,149 telephones, 202 miscellaneous. The number of battery cells, 250,276. The total telegraph traffic amounted to 28,757,468 messages, and the total receipts, 33,954,039 marks (about £1,700,000). The telephonic service had 13,703 kilometres of line and 134,824 kilometres of wire, 412 central offices, 80,189 telephonic stations, 73,621 subscribers, 93,044 instruments, and 841,141 battery cells. The total number of conversations was 326,314,773, 48,187,966 of which were between different towns.

Personal.—As we announced shortly last week, the late Mr. W. Hooper's estate has now been released from the administration of the Court of Chancery, and the business will in future be carried on as a limited liability concern, under the joint managership of Mr. Jno. P. Hooper, the late receiver and manager of the estate, and Mr. Basil Gee, late of the Telegraph Construction and Maintenance Company, and of Messrs. W. T. Glover & Co., the well-known electric light cable manufacturers. Mr. Jno. P. Hooper has been intimately connected with submarine telegraphy all his life, and Mr. Basil Gee has had a varied experience, first as a pupil of the late Sir Chas. Wheatstone and Robert Sabine, and latterly in submarine and electric light cable work, and we think the united efforts of these two gentlemen augurs well for the resuscitation of this now historical firm.

Madagascar Rubber.—In our issue of November 1st, 1893, we spoke of the developments that were likely to take place in the sale of rubber in Madagascar by the discovery of a new gutta-percha tree. We are now informed by Mr. E. Underwood Harvey, the editor of the *Madagascar News*, that the Prime Minister and Commander-in-Chief of Madagascar has just granted a most valuable concession in the great rubber district of Fort Dauphin, on the south coast of Madagascar, to the Hon. John L. Waller, ex-United States Consul for Madagascar, upon terms by far the more reasonable than any yet granted heretofore to anyone in that country. The concession contains an area of 15 miles square, or 225 square miles, or 144,000 acres. These lands, besides containing abundance of rubber trees and vines, also abound in fine timbers, such as ebony, mahogany, rosewood, teak, &c.

The Chicago Exhibition.—In connection with the Chicago Exhibition, the French Government awarded a certain number of decorations of the Legion of Honour. Among the electricians who have attained this distinction, we may mention M. J. Carpentier, who has been made officer, and Messrs. Mildé and J. Richard, chevaliers.

The Left Bank Sector, Paris.—From time to time we have seen in the *Bulletin Municipal Officiel* notices of a petition from the Electrical Company of the Left Bank Sector, submitting plans for electrical canalisations to be established in various streets. But, up to the present, there are no signs of any work being commenced. We understand that the supply station is not yet in course of construction.

Société Internationale des Electriciens.—The meeting of April 4th was chiefly taken up with elections, but this year there was an interesting address during the summing up of the votes. The results of these elections were as follows:—M. Potier was elected president for the year 1895-6, the vice-presidents are Messrs. D'Arsonval, Sartiaux, Sciama, the secretaries Messrs. Arnoux and Bochet, treasurer, M. Clérac, and the following members were elected:—Messrs. Baron, Bernheim, Blondel, Boulanger, Clerc, Desroziers, Dumont, Ebel, Gaiffe, Guillaume, Larnaude, de Nansouty, de Place, Pollard, Radiguet, Richard, de Romilly, Sautter, Violet. M. André Reynier spoke of the laying of the submarine cable from New Caledonia to Australia, and showed a number of photographs taken on the spot. The cable was made at Calais and laid by the Société Générale des Telephones. The Government contract was made February 3rd, 1893, and on October 16th, 1893, the laying was finished. The total length of the cable was 850 geographical miles. M. A. Reynier gave some explanations as to the conditions laid down by the Administration of Posts and Telegraphs; he then described the shipping of the cable, the starting of the ship, and the various incidents observed during the laying. The entire staff for the expedition was 120 men, nine superintending the work. The laying was quite successful, and on October 16th, 1893, the connection was finally established.

NEW COMPANIES REGISTERED.

Thomas Parker, Limited (40,973).—This company was registered on the 19th inst. with a capital of £75,000, in £10 shares, to carry on business as electrical and mechanical engineers and electricians, and as manufacturers of and dealers in machinery, stores, appliances and apparatus of every description applicable for, or in connection with, the supply or use of electricity or magnetism for any purpose, and to generate, accumulate, and supply electric, magnetic, or any other force for the purpose of light, heat, sound or motion. The subscribers (with 1 share each) are: J. H. Woodward, 6, Brighton Terrace, Merridale, Wolverhampton, electrical engineer; E. S. G. Rees, 15, Merridale Lane, Wolverhampton, electrical engineer; W. Armistead, 15, Rupert Street, Wolverhampton, electrical engineer; C. H. Iles, 38, Larches Lane, Wolverhampton, accountant; L. T. Smith, 22, Darlington Street, Wolverhampton, accountant; M. Wilke, 22, Darlington Street, Wolverhampton, accountant; R. Willcock, 49, Queen Street, Wolverhampton, solicitor. There are not to be fewer than three, nor more than seven directors. Qualification, £1,000. Remuneration, £1,000 per annum, divisible. Registered by Wainwright & Co., 9, Staple Inn, Holborn, E.C.

Williams's Valveless Engine Company, Limited (40,982).—This company was registered on the 19th inst. with a capital of £25,000, in £1 shares, to adopt a certain agreement, and to carry on the business of ironmasters, steel makers, mining, electrical and general engineers, machinists, metal workers and contractors. The subscribers (with 1 share each) are: C. C. Baker, 1, Gresham Buildings, E.C., accountant; A. G. Bessemer, jun., Whitehall Club, S.W., engineer; H. E. Bessemer, 20, Lancaster Road, S.E., gentleman; J. S. Taylor, 3, Pembridge Villas, Putney, clerk; S. Cox, 3, Pelham Road, Wimbledon, accountant; R. Jones,

Crouch Hill, N., clerk; H. A. Deed, 1, Gresham Buildings, E.C., accountant. There are not to be fewer than three nor more than five directors; qualification, £250; remuneration, £250 per annum and percentage, divisible. Registered by S. Cox, 1, Gresham Buildings, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Bell's Asbestos Company, Limited (26,651).—On the 28th of last month this company filed its annual return, which shows that out of a capital of £200,000, in £5 shares, 24,000 shares have been taken up, and that £5 has been called upon each of 17,400 shares. A sum of £87,000 has been received, and £33,000 has been agreed to be considered as paid.

Birmingham Electric Supply Company, Limited (30,296).—This company's yearly return was filed at Somerset House on the 6th inst., and shows that out of a nominal capital of £100,000 in £5 shares, 20,000 shares have been taken up. There has been £2 called on each of 10,000 shares, and the full amount has been called on the remaining 10,000 shares. The total sum received is £70,000.

City of Bath Electric Lighting and Engineering Company, Limited (33,947).—This company's annual return, filed on the 4th inst., shows that, out of a nominal capital of £60,000 in 5,500 £10 ordinary and 50 £100 founders' shares, 3,384 ordinary and the whole of the founders' shares have been taken up, and that the full amount has been called on 1,134 ordinary shares. The total sum received reaches £11,340, and £27,500 has been agreed to be considered as paid.

Cambridge Electric Supply Company, Limited (36,457).—This company filed its yearly return at Somerset House on the 21st ult. This document shows that out of a nominal capital of £50,000, in £10 shares, 2,775 shares have been taken up, and that £8 has been called upon each. The total sum received in response to calls is £22,200.

Crystal Palace District Electric Supply Company, Limited (18,532).—The annual return of this company, dated December 11th, 1893, shows that out of a nominal capital of £100,000, in £1 shares, 28,586 shares have been taken up, and that £1 has been called on each of 14,420. The total sum received is £17,430; £14,166 has been agreed to be considered as paid; and £3,264 has been forfeited on 3,264 shares.

Bohm & Co., Limited (37,385).—The yearly return of this company has been filed, and shows that out of a nominal capital of £20,000, in £1 shares, 19,999 shares have been taken up, 19,992 of which were issued as fully paid to the vendors. The full amount has been called on the remaining shares; £1 has been paid, and £6 is therefore in arrear.

Smith & Chamberlain, Limited (22,446).—This company filed its last annual return on the 27th ult., which shows that out of a nominal capital of £100,000, in £10 shares, 1,528 shares have been taken up, and that £8 has been called on each. The total sum received is £56, and £12,168 has been agreed to be considered as paid.

Pontypool Electric Light and Power Company, Limited (36,109).—This company's latest yearly return, made up to March 8th last, shows that out of a nominal capital of £10,000, in £5 shares, 953 shares have been taken up; that £5 has been called on each of 509 of these, and £4 on each of the 444 remaining. The total received is £4,341, which includes £20 paid on shares applied for but not allotted.

Mazarron Electric Light Company, Limited (38,277).—This company's statutory return, filed March 19th, 1894, shows that, out of a nominal capital of £15,000 in 500 £10 preference and 10,000 £1 ordinary shares, the whole of the ordinary, and 100 of the preference shares, have been taken up, with the full amounts called on each. A sum of £1,007 has been received, and £9,993 has been agreed to be considered as fully paid.

W. T. Henley's Telegraph Works Company, Limited (13,795).—The yearly return of this company, filed at Somerset House on the 12th inst., shows that, out of a nominal capital of £100,000 in 3,000 preference and 7,000 ordinary shares, all of £10 each, 3,000 preference and 6,837 ordinary shares have been taken up, and that the full amount has been called on each. The total sum received is £98,370.

St. James's and Pall Mall Electric Light Company, Limited (26,015).—The annual return of this company was filed on February 14th last, from which it appears that out of a nominal capital of £200,000, in 100 £1 founders', 19,980 £5 ordinary, and 20,000 £5 preference shares, the whole number of shares has been taken up, duly called, and paid in full.

Galloways, Limited (28,610).—This company has filed its yearly return, which is made up to March 12th, 1894. The document shows that out of a nominal capital of £250,000, in £100 shares, 2,108 shares have been taken up, the full amount called, and duly paid. The total sum received is £210,800.

Hastings and Saint Leonards-on-Sea Electric Company, Limited (16,505).—This company's annual return, made up to the 3rd inst., has just been filed. It shows that out of a nominal capital of £50,000 in £10 shares, 2,261 shares have been taken up. The full amount has been called on these, £22,615 has been received, and £5 paid on five shares has been forfeited.

Gorseinon Electric Light Company, Limited (39,944).—This company's statutory return, filed March 22nd, 1894, shows that out of a capital of £1,000, in £1 shares, 786 shares have been taken up; that £273 has been received (resulting from the 7s. 6d. called on each share); and £21 15s. is in arrear.

Dick, Kerr & Company, Limited (31,602).—This company's annual return, up to the 12th inst., shows that out of a nominal capital of £160,000, in 16,000 ordinary and an equal number of preference shares of £5 each, the whole of the shares have been taken up, and that £5 has been called on each of the preference. A sum of £80,000 has been received, and £80,000 has been agreed to be considered as paid on the ordinary shares.

Scarborough Electric Supply Company, Limited (37,569).—This company has filed its annual return (dated March 20th, 1894), which shows that, out of a nominal capital of £50,000 in £10 shares, 2,450 shares have been taken up, and that £8 has been called upon each. The total received is £19,600.

Hope-Jones Electric Organ Company, Limited.—According to a notice filed at Somerset House on the 11th inst., the registered office of this company is now at 55—7, Argyle Street, Birkenhead, Cheshire.

CITY NOTES.

A Correction.

In our analysis of the St. Pancras accounts last week, a sum of £18,000 was stated to be the revenue in 1891; this item should be omitted altogether. A further error of £11 was made in the revenue for 1893, which should be £14,487 instead of £14,498.

Bournemouth and District Electric Supply Company, Limited.

There has been a fairly steady progress in electric lighting business at Bournemouth during the year 1893. The number of lamps connected on December 31st, 1892, was 8,988 8-C.P., and at the end of 1893 was 14,552, showing an increase of 5,564 during the year. Since the end of last year many more have been connected, and fresh customers are being connected at the present moment.

The accounts for the year show a profit of £1,481. After providing the sum of £444, to pay interest due to end of December last on the £10,000 6 per cent. mortgage debentures, £32 standing at interest account, and writing off the balance of loss brought forward from 1892, a net balance of £974 profit remains. Of this sum, it has been decided to place £615 to depreciation account.

The analysis of the accounts is as follows:

	1891.	1892.	1893.
Total expenditure	—	£32,773	£40,536
Number of units sold	—	—	159,016
Number of lamps connected ...	—	8,988	14,552
Revenue from sale of current ...	—	—	£4,998
Average price obtained per unit..	—	—	7·54d.

Cost of production.	£		Per unit.
Coal	1,243		1·87d.
Oil, waste, water and engine room stores	190		·29d.
Salaries and wages at generating station	749		1·13d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	525	Works cost 4·08	·79d.
Rates and taxes	179		·27d.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges, and insurance	829		1·25d.
Depreciation of buildings and plant account	615		·92d.
Renewal fund account	nil		—
Total	£4,330		6·52d.

Revenue.				Average price obtained per unit.
By sale of current	£4,998	0	0	—
Meter Rents	218	0	0	7·54d.
Sale of Lamps	—			—
Total	£5,216	0	0	7·54d.

Total cost per unit (exclusive of depreciation and renewal accounts), 5·6d.; works cost, 4·08d.

Electric Light Company Returns.

We are glad to announce that the City of London Electric Light Company have decided to issue periodical returns. This is a feature which will be of distinct interest, and other companies would do well to follow. We are quite aware that one or two other electric lighting companies occasionally publish figures, but hitherto there has been no attempt at a system. Of course, in the early stages of a supply business the comparisons will be very wide, but nevertheless they should prove to be extremely valuable.

The first return of the City of London Company is as follows:—

Revenue Return Quarter ended March 31st, 1894.

	Quarter ended March 31st.	Corresponding quarter last year.
	£	£
Revenue from sale of current for public lighting	3,100	2,778
Revenue from sale of current for private lighting, &c.	12,460	5,061
Total	£15,560	£7,839

Increase £7,721.

Number of 8-C.P. lamps connected March 31st, 1894, 84,634. Increase during quarter, 19,293.

Number of 8-C.P. lamps connected March 31st, 1893, 35,275. Increase during corresponding quarter last year, 15,034.

Metropolitan Electric Supply Company.

The seventh ordinary general meeting of the Metropolitan Electric Supply Company, Limited, was held last Monday at Winchester House, Sir John Pender, G.C.M.G., M.P., presiding.

The Secretary (Mr. E. Cunliffe Owen, C.M.G.) having read the notice convening the meeting,

The Chairman said: Gentlemen, the accounts which are in your hands, and which have been prepared in the form prescribed by the Board of Trade, give such full details as to the company's financial working, that it will not be necessary for me to trouble you with more than a few remarks upon them. You will have seen from the capital account that the second £50,000 of the debentures authorised in 1892 has all been issued, making a total of £100,000, nearly the whole of which is held by our shareholders, showing the real interest which is taken by them in the progress and welfare of the company. This issue of debentures brings our capital up to £600,000, which has practically been all expended, while the continual increase of new customers, and the extension of mains, will render it necessary for us to make still further provision for coming capital outlay. Referring to the other side of the capital account, you will find that the expenditure during the year has amounted to £35,072, the greater part of which has gone in mains, and in the necessary apparatus and connections for supplying our new customers. There has also been some expenditure which, though not large in amount, is of considerable importance to the company's welfare. I refer to the outlay at our Manchester Square station and at our Sardinia Street station. In the first of these cases we have found it necessary to alter and supplement the foundations of the engines and machinery, in order to do away with any possible cause of complaint as to vibration, and I may add that these works are also having the effect of materially improving the working of our plant. You have doubtless seen that an action in reference to this question of vibration is in course of being heard. I am, of course, unable to refer to it in detail; but I can assure you that the board is fully alive to its importance, and has left no stone unturned to provide for the interests of the company being properly and adequately guarded. With regard to the expenditure at Sardinia Street, we have sunk a well at the station, and have put down a pumping engine for the supply of water, and from the experience we have gained, we have no doubt that we shall be practically independent of the water company and water rates, and that a very considerable economy will thus be effected in one of our prime necessities. One other point to which I must refer is the item of management charges, which now disappears, for the first time, from the capital expenditure of the year. In dealing with this matter the board has considered it right to allocate a small portion—about £700—of the salaries of the engineers' department direct to the more important items of construction, by way of percentage, as representing the work done by that department in the way of supervision and actual expenses; but no apportionment of general management expenses has been made to capital this year, the time having now arrived when, in the opinion of the board, the whole of such charges should be borne by revenue. This leads me to the consideration of the revenue account itself, which, in one sense, has been somewhat disappointing. When, in November last, we issued a circular to you, referring to the prospects of the company, the board was guided by the fact that in each of the three quarters which had then been completed the income from current had shown an increase of nearly 50 per cent. over the corresponding periods of 1892. We had, therefore, reason to hope that the Christmas quarter, under normal conditions of weather and demand for light, would show a similar increase. Owing, however, to the remarkable absence of fogs—which, except from our point of view, has been so pleasant a feature of the past winter—and to the exceptional brightness of the general weather, the increase of revenue over the Christmas quarter of 1892 was only 8 per cent., and this was in spite of the fact that our customers were increasing in numbers in about the same proportion as usual. But I would remind you that all lighting companies have been seriously affected by the past winter, and I am simply repeating what has already been dwelt upon by the chairmen of all other kindred companies, whether gas or electric. In our case we estimate the falling off at about £10,000, which, after allowing for extra cost of production, would have given an extra 1½ per cent. dividend on our capital. The total income from current has been £64,312, being an increase of £13,500 over 1892, which has been earned at an additional working cost of £6,600, which would have been only slightly increased to earn the larger income to which I have just referred. Looking at the details of this expenditure, it will be seen that, speaking generally, coals have increased by only £2,200, general stores by £800, station wages and salaries by £1,600, and repairs and maintenance by £2,000. With regard to the item of fuel, the board took full advantage of the reduced price of coal at the time the contracts were made last year; but the small increase of cost under this head, as compared with earnings, is not so much due to economy in purchasing as to the fact which the board has always desired to impress upon shareholders—that increase of output does not involve anything like a proportionate increase of cost. The more light we can sell the less per unit does it cost us to produce, and, therefore, the more profitable is our working. This observation also applies to the second item of oil, water, and stores, which needs no further remark. Wages and maintenance make, however, an important item of increase, which is owing to the fact that our Rathbone Place and Amberley Road stations have been working during the year, not as yet to a sufficient extent to earn a large income, but still involving the expense of staff and maintenance as though they were. With all these considerations, the total working cost has been kept down to a figure which is most hopeful for the future. The items remaining for special notice are general management expenses, which now appear for the first time as a full charge against revenue, and the depreciation fund. With regard to management, very considerable economies have been in operation since last year, reducing the total by nearly £4,000 from the cost in 1892, and as to depreciation—to which question the board has given specially careful attention, without laying down any hard-and-fast principle for the future—we are of opinion, at present, that the amount we have advised should be written off—namely, £7,000, with the further £1,000 off preliminary expenses—fairly meets the case, more especially having regard to the fact that our business compels us to maintain our buildings and plant in the greatest condition of excellence and efficiency, the whole cost of which up-keep is charged direct to revenue, as is apparent from the figures before you. We now come to the final result as shown in the net revenue account No. 5, namely, a net balance, after providing for debenture interest, of £13,548 19s. 4d. With this, we recommend payment of a dividend of 5s. a share, carrying forward £1,073 to next year. We should have liked to recommend a larger dividend, but, under all circumstances, we consider that the progress is very encouraging, and that our business, which I want you to realise is still in process of development, is being established on a firm and satisfactory basis. Our lamp connection is still continuing to increase in very much the same proportion as heretofore, as will be clear to you from the diagram on the wall. You will also notice the plan which shows the houses we supply, and which gives a most encouraging idea of the gradual filling up of our areas, especially those in which we have worked longest. Paddington still lags behind, but that is our newest

district. I ought to mention here that we are of opinion that the time has now arrived for the institution of transformer sub-stations in some of our more crowded districts. By the adoption of this system, which we have always kept in view, we hope to effect a considerable saving in the cost of supply. Before saying more I think it is right to refer to a letter I have received this morning from one of our shareholders. He says that he feels greatly disappointed that in the speech I made last year I referred to a probable dividend of 5 per cent. being declared. You will recollect, also, that that was not in my speech in moving the adoption of the report; but I did say, in answer to a question, with the same confidence as I would to-day, that my belief was strong that, looking to the growth of our system, we should in all probability pay a 5 per cent. dividend. As I have shown you to-day, but for the fact that one quarter had fallen off by £10,000, the dividend of 5 per cent. would have been declared. I mention that to show the uncertainty and the changes that may take place from time to time. But I am pleased to tell you to-day that in the March quarter of the current year our gross revenue amounts to £24,000; in 1893, for the same period, it amounted to £19,000; for 1892 it amounted to £13,000; while in 1891 it amounted to £10,000. You will, therefore, see that I am justified in saying to you to-day that I look forward with the greatest confidence to a 5 per cent. dividend at the end of this year. In saying that, however, I want you to understand that we are engaged in a new system altogether, which is not yet developed; but when I tell you that at the present moment our machinery would produce in about 40 days all the power which we use in the course of the year, you will gather that we have a large amount of unproductive electricity at our command, and I hope by-and-bye we shall have customers to use it. There are other prospects connected with this system which we may look forward to. This electrical power is used for other purposes than electric lighting, but, so far, we have not touched any of these. We know what our electric power is. We have got these large buildings and our mains laid down to serve our customers, and there is no doubt that in these days of active competition some means will be found of employing the enormous waste which exists at the present moment. We have not the power which the gas companies have of storing our electricity in great reservoirs, but if, with scientific progress and development, we can establish some cheap system of storing electrical power in large quantities, it would add enormously to the dividend-paying power of this and kindred companies. I know that a great many people in going into these concerns are under the impression that the directors can do anything they please; but we have to learn by experience, as you do. After very careful investigation, we made the calculation at the time the company was formed that we should receive at least £1 a light. I was rather pulled up for mentioning such a low figure, and other experts put it at 25s. and 30s. per light. The average price of our light to-day is 8s. 9d. That is one of the difficulties we have had to contend against. I, however, have perfect confidence in the future of electric lighting. It has so many advantages that I cannot conceive of its being otherwise than prosperous. It remains, however, for your directors to carefully use all the knowledge and experience they possess to endeavour to increase the dividend paying power of this company. We have to contend against a great many difficulties which have been set up by the Board of Trade. The officials of the Board of Trade, it is true, are able men, but they are not geniuses or experts of this particular system, and they do not know so much as we know. I think the time will come—and that very soon—when the different electric companies will have to meet and consider the question of approaching the Board of Trade with the view of inducing it to alter the restrictions and obstructions imposed upon electric lighting companies, which do not give them fair play. Until we get fair play we shall not be satisfied. There is competition, as you know, between the different companies. One company wants to do a little better than its neighbour, and there is a little of what is called cutting, which I hope will be eventually stopped, and that we shall establish our system upon a broad and honourable basis, namely, that those who do the work the best will get the work, and that we shall not be dependent upon making a small reduction here to-day and another small reduction to-morrow, because that will not promote an understanding with one another to protect our mutual interests. I think I have given you the whole of the details in my power. I hold that we have the nucleus of an important business, and if we watch it carefully its development will be such as will satisfy us and you. I beg to move: "That the report and accounts for the year ended December 31st, 1893, presented to the meeting, be and are hereby approved and adopted, and that a dividend of 5s. per share on the whole of the ordinary shares of the company be and the same is hereby declared, such dividend of 5s. per share to be payable on May 1st, 1894, to all holders on the company's register on April 17th."

Lord John Hay, K.C.B., seconded the motion.

Mr. Howard Young called attention to the large amount of working expenses, and moved an amendment to the effect that the remuneration of the directors be reduced to £800 per annum.

The amendment was seconded by Mr. Munroe.

Mr. Adams inquired how many lights could be laid on with their present machinery.

The Chairman stated that he was informed by the solicitor that the amendment was out of order. In criticising the expenses, the shareholders must remember that they had a larger area than any other company, and had already laid down about 70 miles of mains. In reply to Mr. Adams, they could, with their present machinery, supply certainly 50,000 more lamps, and probably double that quantity.

The motion was then put, and carried unanimously.

Lord John Hay, G.C.B., Mr. J. C. Parkinson, and J. D. Pender, having been re-elected directors, and Messrs. Deloitte, Dever, Griffiths and Co., reappointed auditors, a vote of thanks was given to the chairman and board, and the proceedings terminated.

Brazilian Submarine Telegraph Company, Limited.

The report of the directors for the half-year ended December 31st, 1893, to be submitted to the forty-first ordinary general meeting on May 2nd, 1894, states that the revenue for this period amounted to £96,261 16s. 6d., and the working expenses to £24,284 12s. 4d. After providing £12,880 for debenture interest and sinking funds, and £1,423 1s. 9d. for income tax, there remains a balance of £57,674 2s. 5d., to which is added the sum of £3,533 6s. 9d. brought forward from June 30th last, making a total of £61,207 9s. 2d. First and second interim dividends, amounting to £39,000, have been paid, and £20,000 transferred to the reserve fund, leaving the sum of £2,207 9s. 2d. to be carried to the next account. The receipts for the half-year include the sum of £1,500 dividend to June 30th, 1893, on the company's shares in the African Direct Telegraph Company, Limited. In accordance with the provisions for repayment of the first issue of debentures, dated 31st July, 1884, 187 bonds, representing £18,700, were drawn on the 20th inst. for payment at par on July 31st next. By this payment the first issue of debentures will be extinguished, and a reduction will be effected in the expenses of £19,360, the annual amount of the sinking fund and interest now payable in respect of this issue. The new land lines between Buenos Ayres and Valparaiso, constructed by the Pacific and European Telegraph Company, Limited, in which this company has acquired a considerable interest, were opened for public service on March 19th last, with satisfactory and promising results. This company is thereby again enabled to carry traffic to and from the West Coast of South America, and the public are thus afforded further facilities for telegraphic communication. The various sections of the company's line are in good working order.

General Electric Company (New York).

The second annual report states that this company represents the union of the Edison Electric Light Company, the Edison General Electric Company, the Thomson-Houston Electric Company, and the Thomson-Houston International Electric Company. To acquire these companies the General Electric issued $30,459,700 common stock and $4,251,900 preferred stock, and afterwards sold for each $10,000,000 debenture bonds, the total being $44,711,600. The obligations of the company, direct and indirect, on January 31st, 1894, amounted to $1,984,000, representing a reduction of debt since July 31st, 1893, of $6,750,000. The number of local companies operating incandescent and arc lights has increased from 1,158 in 1892, to 1,277 in 1893, and 1,479 at the beginning of 1894. The total number of electric railway companies has increased from 214 in 1892, and 435 in 1893 to 541 at the beginning of 1894. The consolidated balance-sheet shows assets amounting to $45,928,449.23, including $12,454,967.42 profit and loss. The liabilities are $44,711,600 stock and bonds; $26,200 mortgages; $1,150,759.45 interest and notes, and $39,889.78 sundry credits, a total of $45,928,449.23. A statement of profit and loss shows on the debit side interest, dividends, taxes, and Worlds Fair expenses, $2,592,378.95, and amounts now charged off $14,687,466.12, and on the credit side, surplus, January 31st, 1893, $1,024,954.59; manufacturing and selling profit, $3,189,884.37; dividends and interests, $433,293.06. Interest, discount and exchange, $76,745.63, and debit balance carried forward, $12,454,967.42; total, $17,179,845.07.

Stock Exchange Notices.—Applications have been made to the Stock Exchange Committee to allow the following securities to be quoted in the Official List:—Telegraph Construction and Maintenance Company, Limited, £150,000 5 per cent. debentures, in lieu of £150,000 5 per cent. bonds, expired January 1st, 1894.

The Committee have also appointed a special settling day as under:—Friday, April 27th, City of London Electric Lighting Company, Limited, partly paid scrip of £100,000 5 per cent. debenture stock, and ordered the undermentioned securities to be quoted in the Official List:—City of London Electric Lighting Company, Limited, partly paid scrip of £100,000 5 per cent. debenture stock; National Telephone Company, Limited, further issue of £74,983 4½ per cent. debenture stock; Oriental Telephone and Electric Company, Limited, 171,504 shares, Nos. 1 to 171,504, in lieu of those of the old company of the same name; W. T. Henley's Telegraph Works Company, Limited, 6,837 ordinary shares, Nos. 602 to 1,091 and 1,182 to 7,528.

The Sheffield Electric Light and Power Company.—A meeting of the directors of this company was held on 18th inst., when the applications for the new shares were considered and allotments duly made. The capital required has been fully subscribed.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending April 22nd, 1894, amounted to £886; week ending April 23rd, 1893, £851; increase, £35; total receipts for half-year, 1894, £14,612; corresponding period, 1893, £14,568; increase, £44.

The Western and Brasilian Telegraph Company, Limited. The receipts for the week ending April 20th, after deducting 17 per cent. of the gro receipts payable to the London Platino-Brasilian Telegraph Compan Limited, were £2,940.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, April 18th.	Closing Quotation, April 25th.	Business done during week ended April 25th, 1894. Highest.	Lowest.
184,500£	African Direct Teleg., Ltd., 4 % Deb.	100	...	...	...	100 —103	101 —104	...	...
1,134,640£	Anglo-American Teleg., Ltd.	Stock	£2 12s.	£2 15s.	£2 11s.	42 — 44 xd	42 — 44	...	...
2,932,680£	Do. do. 6 % Pref.	Stock	£5 5s.	£5 10s.	£5 2s.	80 — 81 xd	80 — 81	81½	80¼
2,932,680£	Do. do. Defd.	Stock	...	...	...	7⅜— 8¼	7⅜— 8¼	7⅜	...
130,000	Brazilian Submarine Teleg., Ltd.	10	8 % §	6½% §	6½% §	11¾— 12¼	11⅝— 12¼	12⅛	11⅝
18,700£	Do. do. 5 % Bonds	100	...	...	...	100 —103	100 —103	...	...
75,000£	Do. do. 5 %, repayable June 1906	100	...	...	...	108 —112	108 —112	110	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	... §	10%‖ §	... §	1½— 2½	1½— 2½	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	146 —150	146 —150	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	3½% §	2 % §	... §	1/16 — 3/16	1/16 — 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12 — 13	12 — 13	12⅝	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	18 — 19	18 — 19	...	...
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4½%	4 %	4 %	2½ 3	2½— 3	3	2¾
6,000	Do. do. 10 % Pref.	5	10 %	10 %	...	8½ 9	8½— 9	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½% §	3½% §	...	9 — 9¼xd	9 — 9¼	9½	9 7/16
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½% §	...	14⅞— 15⅛xd	14⅞— 15⅛	15 1/16	14⅞
70,000	Do. 6 % Pref.	10	6 % §	6 % §	...	16 — 16½xd	16 — 16½	16¼	...
105,900£	Do. 5 % Debs., repay. August, 1899	100	...	...	...	107 —110	107 —110	...	...
1,294,100£	Do. 4 % Mort. Deb.	Stock	...	...	...	114 —117	114 —117	116½	115½
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	15⅛— 15¾	15⅝— 15⅞	15 13/16	15 9/16
62,700£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	...	...	...	103 —106	103 —106	104¾	...
222,800£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	...	...	...	103 —106	103 —106	104¼	...
320,000£	Do. 4 % Deb. Stock	Stock	...	...	...	113 —116	113 —116	115¼	114½
95,100£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	...	...	...	103 —106	103 —106	...	...
129,100£	Do. do. do. to bearer, 2,344 to 5,500	...	...	...	...	103 —106	103 —106	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	...	...	...	104 —107	104 —107	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	...	...	...	107 —110%	107 —110%	108½	...
180,227	Globe Telegraph and Trust, Ltd.	10	5¼% §	4⅞% §	4⅝% §	8⅝— 8¼xd	8⅜— 9	9 1/16	8⅜
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	6 % §	15½— 15⅝xd	15⅛— 15⅜	15⅜	15⅛
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜% §	8⅜% §	8 3/10 %	21¾— 22¼	21¾— 22¼	22⅛	...
200,000£	Do. do. do. 5 % Debs.	100	...	...	...	104 —107	104 —107	106	105½
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	...	45 — 47	45 — 47	47	46½
37,548	London Platino-Brazilian Teleg., Ltd.	10	...	...	...	4 — 6	4 — 6	...	...
100,000£	Do. do. 6 % Debs.	100	...	...	...	106 —109	106 —109	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	¼— 1¼	½— 1½	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	...	...	...	1 — 2	1 — 2	...	...
484,597	National Teleph., Ltd., 1 to 438,984	5	6 % §	5 % §	...	4⅝— 4⅞	4⅝— 4⅞	4⅞	4¾
15,000	Do. 6 % Cum. 1st Pref.	10	...	...	...	15 — 16	15 — 16	15	...
15,000	Do. 6 % Cum. 2nd Pref.	10	...	...	...	14½— 15½	14½— 15½	14 9/16	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	...	...	...	5⅜— 5⅝	5⅜— 5⅝	5 9/16	5½
925,017£	Do. 4½ % Deb. Stock Prov. Certs. ...	...	...	...	...	116 —118	116 —118	117	116
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... ...	... ...	...	...
220,000	Oriental Teleph., Ltd., 80,001 to 300,000; 11s. paid ...	1	2¼%	3⅝%	4¼%	... ...	⅝— ¾	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	...	...	...	102 —105	102 —105	...	...
11,839	Reuter's Ltd.	8	5 %	5 %	...	5½— 6½	5½— 6½	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	112 —117	111 —116	115	111
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1½— 2	1½— 2	1⅝	...
146,370£	Do. do. 5 % Debs.	Stock	...	...	...	90 —100	90 —100	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	4 %	..	...	3 — 5	3 — 5	...	...
249,900£	Do. do. do. 5 % Debs.	100	...	...	...	100 —103	100 —103	102½	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	2½— 3	2½— 3	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	...	...	...	102 —106	103 —107	106	105
64,242	Western and Brazilian Teleg., Ltd.	15	4 %	2½%	...	7½— 8	7¼— 7⅜	7⅝	7 9/16
33,129	Do. do. do. 5 % Cum. Pref. ...	7½	...	...	...	6 — 6½	6 — 6½	6½	...
33,129	Do. do. do. 5 % Def.	7½	3 %	...	...	2 — 2½	2 — 2½	2 1/16	...
178,200£	Do. do. do. 6 % Debs. "A," 1910 ...	100	...	...	...	105 —108	106 —109	...	...
222,700£	Do. 6 % Mort. Debs., series "B," red. Feb. 1910	100	...	...	...	105 —108	106 —109	...	...
88,321	West India and Panama Teleg., Ltd.	10	¼%	¼%	...	1½— 1⅝	1½— 1⅝	1½	...
34,563	Do. do. do. 6 % 1st Pref. ...	10	...	...	...	10¼— 10⅜	10¼— 10¾	10⅝	10½
4,669	Do. do. do. 6 % 2nd Pref. ...	10	...	...	...	9 — 10	9 — 10	...	...
80,000£	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	...	...	...	107 —110	108 —111	110	...
$1,214,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	...	...	...	113 —118	113 —118	...	...
169,000£	Do. do. 6 % Ster. Bonds.	100	...	...	...	100 —104	100 —104	...	...

ELECTRICITY SUPPLY COMPANIES.

20,510	Charing Cross and Strand Electy. Supply, 1 to 6, 215 to 718, and 10,001 to 30,000	5	...	5 %	4½%	4 — 5	4 — 5	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,000—180,000	10	...	...	...	11¾— 12½	12 — 13	12¼	12 3/16
20,000	Do. do. 6 % Cum. Pref., 1 to 20,000	10	...	6 %	6 %	13¼— 13⅜	13¼— 13⅜	13½	...
19,900	*Electy. Supply Co. of Spain, 101 to 20,000...	5	...	...	...	... ...	... ...	...	...
5,523	†Liverpool Electric Supply, £4 10s. paid	5	...	...	...	5¼— 5⅝	5⅞— 6¼	5⅝	5⅝
39,477	Do. do.	5	4½%	5 %	5 %	6¼— 6⅜	6¼— 6⅝	6⅜	6¼
49,900	*Metropolitan Electric Supply, Ltd., 6,101 to 50,000 ...	10	1 %	2 %	...	7¼— 7⅜	7¼— 7⅜	7 11/16	7¼
100,000£	Do. 5% Deb., 1 to 10,000 in bonds of £10, £20, £40	...	...	...	...	106 —109	106 —109	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	...	4½— 5½	4½— 5½	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	8½%	7¼%	4½%	6¼— 6⅝	6⅝— 7¼	7	6 9/16
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8 — 8½	8 — 8½	8⅜	8 3/16
59,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	...	3½%	4 %	5⅜— 6¼	5⅜— 6¼	6 1/16	6

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ¶ Dividends paid in deferred share warrants, profits being used as capital.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, April 18th.	Closing Quotation, April 25th.	Business done during week ended April 25th, 1894. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	...	6 % §	6 % §	2⅞ — 3⅛	2⅞ — 3	3	2 1/16
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	...	6 % §	6 % §	2⅛ — 2⅜	2⅛ — 2⅜	2 5/16	2⅛
125,000/	Do. do. 4½ % Deb.	Stock	...	...	...	108 —111	108 —111	...	...
630,000/	City and South London Railway	Stock	...	⅝%	⅝%	27 — 32	27 — 32	...	...
20,000	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 20,000	5	7 % §	7 % §	7 % §	3¼ — 3⅜	3¼ — 3⅜	3⅜	...
50,000/	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	...	...	...	95 —100	95 —100	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	...	...	...	½ — 1	½ — 1	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	...	...	...	1⅛ — 2	1⅛ — 1⅜	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd., 1 to 66,750 ...	2	*nil*	*nil*	*nil*	⅛ — ⅜	⅛ — ⅜	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil* ¶	*nil*	*nil*	⅛ — ¾	⅛ — ¾	...	...
67,385	Elmore's Wire Mfg., Ltd., 1 to 67,385, issued at 1 pm. ...	2	*nil*	*nil*	*nil*	½ — ¾	½ — ¾	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	*nil* §	½ — 1½	½ — 1½	...	...
12,134/	Greenwood & Batley, Ltd., Ord., 4,667 to 16,800	10	...	...	...	4½ — 5½	4½ — 5½	...	...
9,600/	Do. do 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	...	...	6½ — 7⅛	6½ — 7⅛	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	12½%	23 — 24	23 — 24	23⅝	23¼
200,000	Do. do. do. 4½ % Deb., 1896	100	...	...	...	101 —103	101 —103	...	...
11,334	International Okonite, Ltd., Ord., 22,667 to 34,000 ...	10	5 % §	...	...	1 — 2	1 — 2	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	...	1 %	5¼ — 5½xd	7 — 7¼	7¼	...
6,295	† Do. do. Pref., £8 paid	10	...	...	...	9 — 9¼xd	12¾ — 13¼	13	...
78,949	Swan United Electric Light, Ltd., £3½ paid	5	11 % §	10 % §	7½% §	2 — 2⅛	2 — 2⅛	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	15 %	20 %	38 — 40	39 — 41	39¾	39
150,000/	Do. do. do. 5 % Bonds, red. 1894	100	...	...	...	... ...	... ...	...	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50°/ for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0°/ §; 1891—7°/ §; 1890—8°/ §.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5¼—5¾.

Electric Construction Corporation, 6 % Debentures, 87—92.

Electric and General Investment, shares of £5 (£1 paid), 1⅜—2¼.

Electricity Supply Corporation, Ordinary of £5, 5—5¼.

House-to-House Company (£5 paid), 1—1½.

Do. do. 7 % Preference, of £5, 5¼—5¾.

Do. do. 6 % Debentures of £100, 101—103.

Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 4⅞—5⅛; 1st Preference Cumulative 6 %, £5 (fully paid), 6⅛—6⅜.

Liverpool Electric Supply, £5 (fully paid), 6½—6⅝.

Do. do. £3 10s. paid, 4½—4⅝.

London Electric Supply Corporation, £5 Ordinary, ⅞—1⅛.

Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, 101—103.

Yorkshire House-to-House Electricity Company, £5 Ordinary Shares (£4 10s. paid), 4⅛—4⅜.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

Cost of Electrical Energy. By R. E. Crompton, M.Inst.C.E., Vice-President. (Read Thursday, April 26th, 1894.)

I address this paper to all who are interested in electrical supply, but especially to the engineers who design and who work electrical supply plant. It is almost exactly six years since I read a paper before this Institution* on this subject, and three years since I read a similar paper before the Institution of Civil Engineers.†

I should be glad if those who are really interested in the subject would find time to glance over these two papers after reading the present one, as there is much contained in them which might have been repeated here with advantage, if I had not feared to unduly lengthen the paper.

For convenience and brevity I use the word "works" for the whole plant of an electric supply company; such works may have several generating stations. I use throughout the word "energy" for the electrical energy, and I speak of the two well-known systems of distribution as "direct" or "converted" systems. By direct systems I mean all two, three, or other multiple wire systems, with or without storage, in which the energy is supplied direct from the dynamos to the mains, and from the mains to the users, without change of pressure. I include amongst converted systems all those in which the energy is either generated at a high pressure, or converted up to a high pressure for transmission through the mains, and afterwards converted to the lower pressure at which it is supplied to the users.

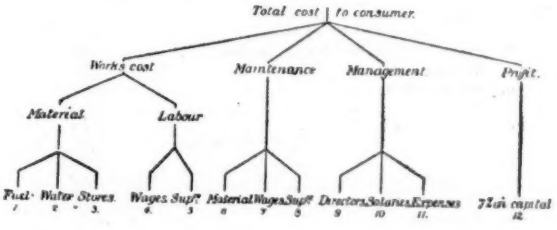
In this paper I do not deal with works using water-power, but solely with those in which the electrical energy is obtained from fuel.

The total cost to the user may be grouped under four heads—

Works cost; maintenance; management; profit.

These may be conveniently subdivided into 12 sub-heads or divisions, as follows:—

Table I.



Of these 12 heads I propose to deal at length with 1 to 8 only. The remaining heads of management and profit are outside the province of us engineers, except in one important particular, which is that the interest or profit to be paid on the capital employed is affected by the choice of system used, and by the skill of the designer of the works, so that it is necessary for us to deal with it.

Let us assume that our ideal works are designed for the most economical production of 5,000,000 units of energy per annum, distributed to users in a large town, and under average conditions. We are now in a position to estimate with considerable accuracy that the capital required for the preliminary expenses, for obtaining the requisite Parliamentary powers, and for the complete equipment of such works will not exceed £500,000, or at the rate of 2s. per unit sold per annum. I have arrived at this figure after considerable study of the capital account of existing companies, and of works carried out by local authorities, and I find that it is nearly certain that several existing works will reach this figure as soon as their plant is completed to the scale intended, and worked to the full output; so that if we consider that entirely new works could now be certainly carried out at a lower cost than that of any existing works, it will be seen that my estimate is on the safe side.

Now I think that such works ought to be able to include in the total cost to the consumer such a sum as profit as will yield 7 per cent. per annum on the whole of the loan, as well as the subscribed capital. In the case of a local authority, a portion of this 7 per cent. would be applied to paying the interest and sinking fund on the original loan, and the remainder would be applied as a profit in the reduction

* *Journal* Institution Electrical Engineers, Vol. xvii., p. 349.

† *Proceedings* Institution Civil Engineers, Vol. cvi., p. 2.

of local burdens or in introducing local improvements; but in the case of a joint-stock company, this capital of £500,000 might advantageously consist of £200,000 in ordinary shares, £100,000 in 6 per cent. preference stock, and £200,000 in 4 per cent. debenture stock, so that the average of 7 per cent. on the whole £500,000 might be divided up as follows:—

4	per cent. on	debenture stock	£8,000
6	„	on preference stock	6,000
10½	„	on ordinary stock	21,000
		Total	£35,000

This sum of £35,000 is equal to a profit of 1·68d. per unit sold. The cost of managing such a company can also be dismissed in a few words. Under this heading it is convenient to group directors' fees, salaries of managing staff and office, meter readers, collectors, all stationery, law, and audit charges, rates, taxes, and insurance. If we take the practice of the best-managed works as a guide, we find that about £8,200 per annum is sufficient to cover all these charges for the largest output that has been yet obtained. It is evident that a sum of £9,000 a year would be an ample one for the management charge on the output of 5,000,000 units. This management charge, therefore, works out at 0·42 a unit.

You will see, then, that at the scale of working that we are now considering, which is at a scale of output certain to be reached within a year or two by a large number of works, the management and profit items, taken together, should amount to 2·1d. per unit. As I have said above, we engineers have nothing to say in controlling these figures. They are certain to be reached in the course of a few years, as it is a mere question of output. The question which I now propose for your consideration is this: What chance have we of reducing the present works cost and maintenance cost included in the sub-heads 1 to 8 to such an extent that the energy may be sold to the public at, possibly, the low figure of 3d. per unit? I believe that Mr. Swinburne has stated that electrical energy, whenever the demand is continuous, such as for certain electrolytic or electro-metallurgical processes, can be generated and distributed to short distances at a works and maintenance cost of ¼d. a unit. I believe Mr. Swinburne has good grounds for this estimate, if cheap fuel is available. But for our present purpose, which chiefly concerns the supply of electrical energy used largely for electric lighting, and to a minor degree for power, we cannot fix such a low figure for our ideal works and maintenance cost for the future. Mr. Swinburne's case and those which we are now considering differ so widely. We can hardly hope for many years to come to improve the load-factors of works for general supply much above 20. The average of the London stations is still a long way off this figure, and I fear that the extensions of the use of energy for power and purposes other than lighting are likely to go on for some years to come at a slow rate. At a load-factor of 20 you must remember that all maintenance charges work out nearly five times as great as they would be if the output was continuous. It is useless to put before you ideal figures which we cannot hope to approach. I propose, instead, to adopt figures which we may hope to reach at no distant period, and have therefore prepared those given on Table II., and I give reasons for fixing on them as I deal with each sub-head in turn.

Table II.—Ideal Standard Works Cost.

		d.	d.
Works Cost:—			
	Cost per unit sold.		
1.	Fuel—2·5 lbs. Welsh coal at 20s.	0·27	
2.	Water	0·01	
3.	Petty stores	0·02	
4.	Wages	0·10	
5.	Superintendence	0·10	
	Total works cost	——	0·5
Maintenance:—			
6.	Material on repairs	0·20	
7.	Wages on repairs	0·15	
8.	Superintendence	0·05	
		——	0·4
9. 10. 11.	Management		0·42
12.	Profit		1·68
			3·00

Working expenses, 44 per cent. of receipts.

Fuel and Water.—Divs. 1 and 2.—Fuel.

I agree with Prof. Kennedy in the remarks that he made on my paper read before the Institution of Civil Engineers * that the importance of the cost of the fuel used on electrical energy supply works is not to be measured merely by the money spent on the fuel itself, but that it is, to a certain extent, a measure of the quantity of plant that must be employed, and so affects the cost of upkeep of the plant, and to some extent every cost item, except, perhaps, management and profit items.

At a very early stage in the history of electrical supply works it was found that in practice the amount and cost of the fuel used differed very widely from the amount estimated from the known efficiency of the plant.

In 1883 modern engine builders were making engines and boilers using less than 2½ lbs. of good coal per I.H.P., and the mechanical efficiency of these engines was certainly not less than 85 per cent. At that time dynamos could be made of 85 per cent. efficiency. We all thought that our distribution losses should not exceed 15 per cent.; so that, putting these figures together, we were justified in hoping that our fuel bill would not exceed 5½ lbs. of coal per unit sold. We soon, however, found that in practice we could not approach such a degree of economy; so that the opinions of practical engineers in charge of supply works rapidly veered round to the opposite extreme, and among these gentlemen, even in 1888, when I estimated that the figure which was then prevalent of about 24 lbs. of good Welsh coal used per unit sold might in the future be reduced to 5⅝ lbs., I met with much incredulity. At so late a date as that of my paper before the Institution of Civil Engineers in 1891,* Mr. Raworth, in the course of discussion, stated that to his knowledge from 19 to 22 lbs. of coal was commonly being used, and that he considered the figures I then gave—namely, 7·9 lbs. for the Kensington and 6·5 lbs. for St. James's stations, for the best months of the year—were so satisfactory that they opened up a prospect of a new era for shareholders in those companies. I am glad to say that since that date improvement has been very regular; during the past year we have several times seen recorded during the winter months—in which, of course, the economy of fuel is at its best—a fuel consumption under 5 lbs. of Welsh coal per unit sold; so that my forecast, made six years ago, has already been more than justified.

I have arrived at my new possible or ideal figure of 2½ lbs. of Welsh coal per unit sold in the following manner:—I find that we can in London count on obtaining this coal having an average calorific value of 14,500 B.T.U. per lb. With proper arrangements for heating the feed water to nearly boiling point boilers can be obtained which will evaporate 12 lbs. of water at our working pressure of 150 lbs. I think that the losses due to irregular working and banking fires can be so minimised that 2½ lbs. may evaporate 25 lbs. of water into dry steam—not on tests only, but as shown on the monthly bills. Condensing steam engines can and will be made for us using not more than 12 lbs. of steam at from three-quarters to full load, or 13 lbs. of steam at from half to three-quarters load per I.H.P. per hour. To these engines dynamos can be coupled direct of such efficiency that the combination will not use more than 18½ lbs. to 20½ lbs. of steam per unit per hour, measured at the dynamo terminals at the corresponding loads, so that an average of 20 lbs. per unit generated may be counted on during the time that these engines are actually at work. This allows for 10 per cent. of the steam evaporated being condensed in the pipes, or used in feed pumps or other obscure sources of loss, and a further 10 per cent. for our distribution loss, in order to account for the 25 lbs. of water I require to be evaporated by the boilers.

It appears to me that the most convenient method of discussing the problem of reaching these ideal figures is to consider in turn the fuel that we use and the boilers and other steam-producing apparatus, the engines for using the steam, the dynamos for generating the energy, and, finally, the means for distributing the energy to the users—in each case with a view of locating the losses that now take place, and considering the best means of minimising these losses as far as may be possible.

In London the favourite fuel hitherto used in electric supply works has been Welsh coal of the best quality, as it has been found that the cost of the carriage of fuel forms such a large part of its total cost when delivered on to the works, that in most cases it pays best to use nothing but fuel of the highest calorific value. This value in the case of the best Welsh coals may be taken at 14,500 British thermal units; for, although values as high as 16,700 have been noted in the case of Nixon's and a few other Welsh coals, yet it is probable that these exceptional values are not attained on the average, even from coals from the very same seam.

As our ideal figure of 2½ lbs., therefore, contains 36,250 B.T.U., it will be convenient, for purposes of comparison, or for considering the use of other fuels, to point out that 2½ lbs. of Welsh coal is equal to 36½ B.T.U. per watt-hour of the energy sold.

Table V. gives the calorific values of various fuels, determined by Bryan, Donkin & Co., Limited, arranged in the order of their efficiency when used in a Lancashire boiler fitted with Perret's furnace:—

Table V.—Calorific Values of various Fuels, determined by Messrs. B. Donkin & Co., Limited.

Fuel.	Description.	Where from.	Value in B. Ther. U.	Evaporation in boiler per lb. of fuel, lbs. of water from 80° F. at 50 lbs. pressure.	Clinkers and ash, &c.	Efficiency of boiler.
						per ct.
Coal ..	Large ..	Welsh, best ..	15,500	10·0	2·4	66·5
„ ..	Small ..	Cheshire, Orrel Colliery Co.	14,500	8·7	2·4	64·0
„ ..	Large ..	Welsh, Ocean ..	13,950	7·9	8·5	58·7
Anthracite	Pea ..	„ Llanelly	13,840	7·7	5·2	57·0
„	Nuts ..	„ „	13,560	7·7	6·6	58·5
Coal ..	Large ..	„ Ffaldau ..	13,560	7·7	9·5	58·5
„ ..	„ ..	Yorkshire Ravensworth	14,820	7·5	10·5	51·0
Coke ..	„ ..	London	—	6·85	—	—
Coal ..	Dust ..	Welsh	—	6·78	7·1	—
„ ..	Small ..	Nottingham ..	11,630	6·5	12·9	58·0
Anthracite	Dust ..	Welsh	13,700	6·35	6·2	47·0
Coke (ord.)	Breeze ..	London	10,610	5·4	19·6	52·5
Coke ..	„ ..	Welsh (Ebbw) ..	12,000	5·4	5·5	46·0
„ ..	Dust breeze	Nottingham ..	11,200	3·7	20·0	33·8
„ (pan)	Breeze ..	London	8,840	3·22	28·6	—
Refuse ..	House (unsorted)	„	—	2·13	—	—

* *Proc.* Inst. C.E., Vol. cvi., p. 2.

* *Proc.* Inst. C.E., Vol. cvi., p. 2.

I have been enabled, through the kindness of Messrs. Bryan, Donkin & Co., to avail myself of these figures, which show at a glance the (comparative) value of Welsh coal as compared with other steam coals, of large Welsh as compared with small Welsh, of small anthracite, large and small coke, and coke dust; and, for the information of those who hope for great things from the use of town refuse for steam-raising purposes, I give at the foot of this table Messrs. Bryan & Donkin's determination of its value. The Perret furnaces used for these determinations is well suited for making such a comparison, as it burns efficiently all classes of fuel, even the smaller and finely divided coals, coal dust, coke breeze, and coke dust, and in these cases minimises the loss of small combustible, which is liable to fall through the grate bars. The results shown on this table emphasise the fact that in practice we can utilise a large percentage of the T.U. in such fuels as anthracite, Welsh coal, and coke, the heating power of which lies chiefly in the solid carbon which they contain; and that the small and dust fuels of the same class are only less valuable because a part of them is liable to fall through the bars, and because, being so finely divided, they usually contain more earthy matter to form clinker and ash in the furnace than the larger coals or cokes, which can be more easily hand-picked, sorted, or washed free from such impurities.

The very large class of steam coals used in the Midlands and North is only represented in the table by the one test of the Yorkshire Ravensworth coal, but the majority of these coals, whether large engine coal, nuts, or engine slack, only contain from 50 to 70 per cent. of carbon in the solid form; so that although, on account of the T.U. contained in the combined carbon and in the hydrogen, these fuels, when tested in the calorimeter, may give a calorific efficiency approaching that of the anthracite and Welsh coals, yet we find very rarely that any form of furnace now in use is able to utilise any considerable percentage of these hydrogen units, even when the best of the modern automatic stoking apparatus is used. So that when judging the comparative value of these fuels we should always remember that it is far more difficult to obtain a high boiler efficiency from these latter fuels than from those which contain the larger percentage of carbon in the form of coke. In order that you may conveniently calculate the T.U. contained in a pennyworth of coal of various qualities and prices, I have prepared Table V. (*a*), which shows this at a glance for all fuels from 10,000 up to 16,000 B.T.U. per lb., and for all prices from 5s. up to 22s. per ton.

V. (*a*).—Table showing Number of British Thermal Units in One Pennyworth of Fuel of Various Qualities and Prices.

Price of Fuel in Shillings per Ton of 2,240 *lbs.*

B. Th. Units per lb. of fuel.	5/-	6/-	7/-	8/-	9/-	10/-	11/-	12/-	13/-	14/-	15/-	16/-	17/-	18/-	19/-	20/-	21/-	22/-
10,000	373,300	311,000	266,666	233,333	207,407	186,666	169,600	155,555	143,589	133,333	...	...	...	...	...	...	...	...
10,200	380,800	317,200	272,000	238,000	211,600	190,400	173,100	158,600	146,500	136,000	126,900	...	...	...	...	...	...	...
10,400	388,300	323,400	277,300	242,700	215,700	194,100	176,500	161,700	149,300	138,600	129,400	121,300	...	...	...	...	...	...
10,600	395,800	329,700	282,700	247,300	219,850	197,900	179,900	164,900	152,200	141,300	131,900	123,700	116,500	...	...	...	...	...
10,800	403,300	335,900	288,000	252,000	224,000	201,700	183,300	167,900	155,100	144,000	134,400	126,000	118,600	112,000	...	...	...	...
11,000	410,800	342,100	293,300	256,700	228,100	205,400	186,700	171,100	157,900	146,600	136,900	128,300	120,500	114,100	108,000	...	...	...
11,200	418,200	348,300	298,700	261,300	232,300	209,100	190,100	174,200	160,800	149,300	139,400	130,700	123,000	116,200	110,000	104,500	...	...
11,400	425,700	354,600	304,000	266,000	236,400	212,900	193,500	177,300	163,700	142,000	141,900	133,000	125,200	118,200	112,000	106,400	101,300	...
11,600	433,200	360,800	309,300	270,700	240,600	216,600	196,800	180,400	166,600	154,600	144,400	135,300	127,300	120,300	114,000	108,300	103,100	98,400
11,800	440,600	367,000	314,700	275,300	244,600	220,300	200,200	183,500	169,400	157,300	146,900	137,700	129,600	122,300	116,000	110,200	104,900	100,100
12,000	448,100	373,200	320,000	280,000	248,800	224,000	203,600	186,600	172,300	160,000	149,400	140,000	131,800	124,400	118,000	112,000	106,700	101,800
12,200	455,600	379,400	325,300	284,700	252,900	227,800	207,000	189,700	175,200	162,600	151,900	142,300	133,900	126,500	120,000	113,900	108,400	103,500
12,400	463,000	385,700	330,700	289,300	257,100	231,500	210,400	192,800	178,100	165,300	154,300	144,700	136,200	128,500	121,700	115,800	110,200	105,200
12,600	470,500	391,900	336,000	294,000	261,200	235,200	213,800	195,900	180,900	168,000	156,800	147,000	138,400	130,600	123,600	117,600	112,000	106,900
12,800	478,000	398,100	341,300	298,700	265,400	239,000	217,200	199,000	183,800	170,600	159,300	149,300	140,500	132,700	125,700	119,500	113,800	108,500
13,000	485,400	404,300	346,700	303,300	269,500	242,700	220,600	202,100	186,700	173,300	161,800	151,700	142,800	134,700	127,500	121,400	115,600	110,300
13,200	492,900	410,600	352,000	308,000	273,700	246,400	224,000	205,300	189,500	176,000	164,300	154,000	145,000	136,800	129,500	123,200	117,300	112,000
13,400	500,400	416,800	357,300	312,700	277,800	250,200	227,400	208,400	192,400	178,600	166,800	156,300	147,100	138,900	131,750	125,100	119,100	113,700
13,600	507,800	423,000	362,700	317,300	282,000	253,900	230,800	211,500	195,300	181,300	169,300	158,700	149,400	141,000	133,500	127,000	120,900	115,700
13,800	515,300	429,200	368,000	322,000	286,100	257,600	234,200	214,600	198,200	184,000	171,800	161,000	151,500	143,100	135,750	128,800	122,700	117,100
14,000	522,800	435,400	373,300	326,700	299,300	261,400	237,600	217,700	201,000	186,600	174,300	163,300	153,700	145,200	137,500	130,700	124,400	118,800
14,200	...	441,700	378,700	331,300	294,400	265,100	241,000	220,800	203,900	189,300	176,800	165,700	156,000	147,200	139,500	132,500	126,200	120,500
14,400	...	...	384,000	336,000	298,600	268,800	244,400	223,900	206,800	192,000	179,200	168,000	158,100	149,300	141,500	134,400	128,000	122,200
14,600	...	...	...	340,700	302,700	272,500	247,800	227,000	209,600	194,600	181,700	170,300	160,300	151,400	143,500	136,300	129,700	123,900
14,800	...	...	...	...	306,900	276,200	251,200	230,100	212,500	197,300	184,200	172,700	162,500	153,400	145,500	138,100	131,500	125,600
15,000	...	...	...	...	...	280,000	254,500	233,200	215,400	200,000	186,700	175,000	164,700	155,500	147,200	140,000	133,300	127,300
15,200	...	...	...	...	...	...	257,900	236,300	218,200	202,600	189,200	177,300	166,900	157,600	149,100	141,900	135,100	129,000
15,400	...	...	...	...	...	...	...	239,400	221,100	205,300	191,700	179,700	169,100	159,600	151,000	143,700	136,900	130,700
15,600	...	...	...	...	...	...	...	...	224,000	208,000	194,200	182,000	171,300	161,700	153,000	145,600	138,600	132,400
15,800	...	...	...	...	...	...	...	...	...	210,600	196,700	184,300	173,500	163,800	155,000	147,500	140,400	134,100
16,000	...	...	...	...	...	...	...	...	...	...	199,200	186,700	175,700	165,800	157,000	149,300	142,200	135,800

Fuel and Water.—Divs. 1 and 2.—Boilers, Economisers, &c.

The boilers which have hitherto been chiefly used in electric supply works have been of the locomotive, marine or semi-marine, tubulous, or Babcock and Wilcox type, and the Lancashire type.

Locomotive Type.—Several large locomotive boilers were put in by Mr. W. H. Maw for driving the *Daily Telegraph* printing works, and the success of these was so great that I asked him to design for me boilers of the same type for the first London central station, which my firm put down for the London, Chatham and Dover Railway at Victoria Station in 1883. These boilers had copper fire-boxes, and, on test trials, gave an evaporative efficiency of 8½ to 9 lbs. of water per lb. of Welsh coal. This type is in most respects satisfactory; but, on account of the level of the grate bars being so much below the level of the fire doors, it is difficult to properly clinker the fires—so much so that when a batch of coal is used that contains much clinker, it is very difficult to clean the fires in a reasonable time, so that the evaporative efficiency is thereby much reduced. From this cause the average efficiency of locomotive boilers does not much exceed 7 lbs. of water per lb. of coal when taken from the monthly bills, and under the conditions usually met with in supply works. It is also not an easy matter to bank the fires of a locomotive boiler in an economical manner.

The St. James's and Pall Mall Company have used large boilers of this type, made by Davey, Paxman & Co, and the Metropolitan Company have used others made by Hornsby—all, I believe, with good results. I, however, have been unable to obtain the correct evaporative duty. This type of boiler is rather more costly to maintain than the other types; the fire door ring is liable to give trouble from leakage, and a great deal of space must be wasted in order to give access to the smoke-box end of the boilers for tube sweeping purposes.

The Marine and Semi-Marine Type.—The marine type has been used in a few instances, notably, in the Whitehall Court station of the Metropolitan Company, and is highly economical; but it is a rather costly boiler to construct. Equally good results may be obtained from the semi-marine type, which is a modification of it, made by Messrs. Davey, Paxman and others, which they call the "Economic" boiler; in this boiler the flues are carried right through from front to back, and the products of combustion are deflected back through the tubes by a firebrick back. In Scotland this boiler is called a "dry-back" boiler. It has many merits; it is very simple, and easily repaired; the intensely heated "dry-back" acts as a very good smoke preventer, so that midland steam coals can be used without producing smoke, which is not the case with either the locomotive or Babcock's type. Prof. Kennedy has used a large number of these boilers for the Westminster Supply Company, and, he tells me, with uniformly good results from every point of view. The test of this boiler, given in Table IV., shows it to be of the highest efficiency. I have not personally had much experience in its use until quite recently at the new central station in Shoreditch for the Great Eastern Railway. The sole fault in this boiler (and it is not a great one) is the rather awkward position of the smoke-box over the fire door.

Babcock & Wilcox Boilers.—These boilers, as you well know, consist of a large group of inclined tubes, having the water inside the tubes, the highest end of the tubes being at the firing end of the boiler. The tubes are connected at both ends by special headers to steam drums placed overhead. The firing is carried on on large grates, and the products of combustion are deflected by fire-tile bridges, so that they are obliged to follow a serpentine course through the tubes, the hot gases passing several times transversely to the tubes. My experience in the use of Babcock boilers has been altogether satisfactory, and I believe that the best evaporative efficiency yet obtained in supply works has been with these boilers. I make this statement all the more readily, as in my 1891* paper I said that

* *Proc.* Inst. C.E., Vol. cvi., p. 2.

this class of boiler, presenting, as it does, such considerable radiating surface of brickwork, would not give such economical results during the long hours of standing with banked fires as other boilers which are internally fired; but since that date the skill of the designers, and the great skill and attention of the users, has resulted in so minimising these losses, that I believe these boilers stand quite at the head of the list, not only as regards economical working on full load tests, but also in the small use of fuel when standing banked. These are my own observations, but I understand that the experience of others has been equally satisfactory, at least, wherever Welsh, anthracite, coke, or other smokeless fuels are used. I am told that when used with smoke-producing fuel, there is a tendency for the lower row of tubes to cool down the products of combustion, that these tubes become coated with soot, and the evaporative result is unsatisfactory. I believe, however, that the makers have now introduced special means to get over this difficulty. The chief refinements that those who use these boilers have been able to introduce, and which have led to reduction in the waste of fuel during long hours of light, firing, and banking, are principally in the alteration of ash-pit, flue doors, and dampers, so as to regulate the air admission with great nicety, or to completely shut it off. We also find that the maintenance of the fire-tile bridges between the tubes, which cause the gases to follow the undulating path above described, is a matter of extreme importance; and last, but not least, this boiler should be kept perfectly clean. Up to a few years ago we were content with periodical cleanings and scalings; but now, by the use of suitable boiler fluids, and frequent blowing off at the surface, as well as at the lower cocks, we find that we can keep the interior of these boilers as free from scale, and in all respects as clean, as when they left the makers' hands. Test results with these boilers have shown that $9\frac{3}{4}$ lbs. of water can be evaporated with Welsh coal at 170 lbs. boiler pressure: if the calorific value of this coal is taken at 15,000, this is equal to $76\frac{1}{2}$ per cent. efficiency; and, as my table of costs will show you, in practice we have reached to within a narrow percentage of this figure, even when all banking coal and other sources of waste are taken into consideration.

Lancashire Boilers.—We are told from time to time that the evaporative efficiency of this boiler ought to be the highest, and its maintenance cost the lowest, of any boiler. I believe the latter claim to be better founded than the former. The boiler is easy to clean, and the repairs should be few at low pressures and far between; but it must be remembered that we have no extended experience of the cost of maintenance of these boilers when used at the higher pressures of 140 to 170 lbs. per square inch, now so common in electric works—as, for instance, the maintenance of the usual fusible plug is not an easy matter, and it is therefore necessary to depend on some form of low-water alarm, which is always a troublesome piece of apparatus; again, although the accidental lowering of the water level of a locomotive or a Babcock boiler, or an "Economic" boiler, may have serious consequences, yet these are nothing to what occurs when the flues of a Lancashire boiler come down from this cause.

As regards the evaporative efficiency of the Lancashire boiler, I think it has been somewhat over-rated. Owing to the fact that the great majority of Lancashire boilers are in use in the Midland and Northern counties, where the fuel used is cheaper than that we use in London, and where little or nothing is said if smoke is produced, and where low cost of maintenance is of higher importance than high evaporative efficiency, mill engineers have been led to regard this as the one and only boiler; but that this type is not efficient when taken by itself, is amply proved by the fact that no first-class mill is ever fitted up without the addition of economisers—in fact, we may say that the Lancashire boiler, without its economiser, is only half a boiler. In most cases the gases would leave the Lancashire boiler at 700°, leaving 300° to be taken out of the gases by the economiser; whereas, in tests of the locomotive, marine, semi-marine, or Babcock boilers, the gases leave the boiler itself at a temperature very slightly in excess of that of the steam; so that in this letter case an economiser would be a refinement, and not a necessity. I do not think this fact has been sufficiently brought home to us engineers when the merits of the Lancashire type of boiler have been so persistently put before us by outside engineers, so that many of us—myself included—have made the mistake of putting down Lancashire boilers for supply stations in country towns without economisers, thinking that if we made these boilers large for their work we should get the required economy, whereas with this type the only way to get high economy is to use a rather small boiler and a large economiser. At any rate, the electric works using Lancashire boilers have hitherto not shown at all well in comparison with other types. In towns where the fuel is obtained so near to the works that the cost of carriage is small compared with the actual cost of the fuel itself, it pays to put down boilers fitted with special stoking plant to deal with these inferior fuels. In most of these cases Lancashire boilers have been used, but, as I shall show hereafter, the results hitherto obtained from the use of such cheap fuel have not been very satisfactory; in fact, the very cheapness of the fuel itself has been a snare to the works engineers, causing them to neglect refinements in fuel economy to such an extent that in many cases the greater part of the saving which they ought to have shown from the low price of their fuel has been lost. In some cases the price of their fuel has been actually higher than in the best London works, where economical working has been studied.

It is now time to put before you in a tabular form the data which I have been able to prepare to show the working efficiency of the boiler plant used in 10 of the works which I propose to compare. In all cases the quantity and calorific value of the fuel used is given with sufficient accuracy; but I have not in all cases been able to ascertain the water used per unit with the same accuracy, although this would have been a very desirable check on my other figures.

Table III. shows the actual boiler efficiency observed in these 10 works; I have designated them by letters, which enable you to identify them, in the following tables.

Table III.—Boiler Efficiency.

Works.	System.	Type of boiler.	Fuel. Class.	Fuel. Value in B.T.U.	Lbs. of fuel per unit sold. 1892.	Lbs. of fuel per unit sold. 1893.	Lbs. of water evaporated per lb. of fuel.	Efficiency of Boiler.
								per ct.
E	"Converted" Alternating	Lancashire	Small	11,300	21·0	23·0	4·12	38·0
N	"Direct"	" ..	"	12,000	17·7	17·1	5·0?	43·5
O	"	" ..	"	12,000	16·6	17·0	6·0?	52·0
J	½ "Converted" alternating ½ "Direct" ..	" ..	"	12,000	16·0	14·8	5·2	45·2
I	½ "Converted" alternating ½ "Direct" ..	Babcock and Wilcox ..	Welsh	14,500	14·7	12·0	7·8	56·5
Q	"Direct"	Locomotive	⅔ Welsh ⅓ Coke	..	..	10·2	7·5	54·5
U	"	Babcock and Wilcox ..	Welsh	14,500	8·9	8·0	7·85	57·0
V	"	Economic ..	"	14,500	9·9	7·5	8·0	58·0
W	"	Babcock and Wilcox ..	"	14,500	6·9	5·83	8·5	61·5

In all the tables they are arranged in the actual order of fuel economy, F, showing the largest consumption of fuel per unit sold, and W the smallest.

Table IV. gives the evaporative duty and efficiency of several types of boiler determined at special tests.

I would draw attention to the remarkably high results obtained by Prof. Kennedy, shown on Table IV., in his Glasgow trials; and beg that this result, which was obtained with marine type boilers using small gas works coke, may be compared with that shown by Bryan Donkin, in Table V., with a Lancashire boiler using similar coke.

Referring to Table III., Works J are using Lancashire boilers fitted with automatic stokers of the Vicars type. In this case, which is under my own control, every means has been studied to increase the evaporative efficiency of the boilers; but this is a typical case of the difficulties attending the use of small coal, even if it be of fairly high calorific value. In this case a considerable part of the loss is due to the small coal falling through the bars. The coal supplied is of variable caking quality; sometimes it cakes together sufficiently to reduce this loss; in other cases it hardly cakes at all, and from 15 to 20 per cent. of the combustible is lost. The point I have above referred to of the extreme difficulty of utilising the heat units in the hydrogen is here met with. If the air admission is not managed with the utmost nicety, the losses due to over-dilution of the products of combustion by air become so great that the evaporation is largely diminished, and this without any apparent neglect on the part of the stoker.

Table IV.—Recording Maximum Efficiency of Sundry Types of Boilers at Test Trials.

By whom carried on.	Boiler.	Fuel used. Description.	Fuel used. Cal. value.	Lbs. water evaporated. From and at 212°.	Lbs. water evaporated. From 170° to 150°.	Efficiency.
						per ct.
J. F. Crosland ..	Lancashire ..	Lofthouse unscreened nuts.	12,875	7·74	..	56·5
" ..	With McPhail and Simpson's superheater.	" "	12,723	10·05	9·3	76·3
J. Holliday, at Messrs. Bryan Donkin's Works	Perret's grate with Lancashire.	Welsh small	16,734	9·96	9·2	65·9
" "	" "	Coke dust ..	8,400	6·02	5·5	69·3
Prof. Robinson, at St. Pancras.	Babcock & Wilcox	Welsh ..	15,000	11·9	11·0	76·5
Prof. Kennedy, at Glasgow.	Marine type ..	Coke.. ..	12,120	7·91	7·3	63·0
Prof. Kennedy, at Eccleston Place.	Semi-marine type	Welsh ..	14,866	12·2	11·25	78·0
Prof. Kennedy, Nov. 26th, 1888.	Thornycroft water - tube boiler.	" ..	14,900	13·4	12·4	86·8

Before leaving the subject of boilers, I ought to say a few words on the use of forced draught. A good many of us have formed the opinion that one of the best methods of meeting the short period of heavy load is by the use of forced draught applied to a closed ash-pit, as has been done by Meldrum and others. It is evident that existing boiler plant might, in case of emergency, or for short periods, be forced to evaporate 50 per cent. more steam than at present; and this would be particularly convenient to meet the times of maximum load, so that in this way the waste of fuel due to lighting up extra boilers for these short periods might be reduced or altogether avoided. We should also be able to burn small or finely divided, and hence cheaper, fuel, during the times of light load in an efficient manner. Another method of reducing the cost due to the necessity of lighting up additional boilers for the period of maximum load would be by using liquid fuel, to be used only on emergency, or during these periods of maximum load.

As is well known, Mr. Holden, on the Great Eastern Railway, has been very successful in the use of astatki, or crude petroleum, with

his works boilers, and on some of the locomotives of the Great Eastern Railway. The principal objection to his system appears to be the noise of the blower, and the same applies to nearly all the systems of forced draught, where an injector blower is used; but there seems little doubt that this noise may be minimised by properly arranging the air inlet—that is to say, by drawing the air from a point outside the building, placed so that the noise at the entrance cannot be a nuisance to the neighbours. As it is evident that it is very easy and convenient to safely store such liquid fuel in deep underground tanks, and as is evident, in face of the troubles we have lately gone through from the coal strike, that it is necessary to have such a considerable storage, this question of the employment of liquid fuel deserves careful attention by all interested in supply works.

There is another point to which I wish to call attention. A long and interesting series of articles has recently appeared on water-tube boilers in the *Engineer*, in the course of which the writer more than once states that it is impossible to force any of the existing types of water-tube boilers, as any such forcing invariably results in the production of wet steam, and consequent loss of economy. It is difficult to know how the writer could have formed such an erroneous impression. My own experience is that the works where the best results have been obtained are those where the Babcock & Wilcox boilers have been forced the hardest. At works W, the boilers, which are nominally supposed to evaporate 11,000 lbs. of water per hour, have frequently been forced to 16,000, or about 50 per cent. in excess of the duty guaranteed by the makers, and at such times of heavy forcing there has never been any trace of priming or wet steam.

On the whole I think that there is a fair prospect of improving and supplementing our boiler plant, and our methods of working it, so that we may obtain in the future an average boiler efficiency of 70 per cent., equivalent to an evaporation of 10 lbs. of water at a pressure of 150 lbs. when using Welsh coal, and an equivalent smaller evaporation from inferior and lower priced coal.

Fuel and Water.—Divs. 1 and 2.—The Effect of the Efficiency of Steam Engines on Dynamos or Alternators.

Now that so many supply works have been running for several years, and that the works accounts have been annually published in the full detail demanded by the Board of Trade requirements, so that the actual cost of fuel, water, stores, labour and salaries, and actual output of energy delivered are recorded, and are known to everyone who interests himself in these matters, it might be thought an easy matter to draw some useful conclusions from these published figures, so as to throw light on the comparative efficiency of the various systems and types of plant used in these supply works; but I regret to be obliged to confess that the drawing up of such comparative tables is not an easy matter. I have examined the published accounts of 23 important and representative electric supply works, in order to compare for this part of the paper the cost of the fuel. From these I have prepared Table VI., which relates solely to fuel and water used. I must mention that in preparing this and the other tables, I at first relied on the published accounts for the information as to fuel, stores, labour, and salaries; but as I found that several serious mistakes existed in the published analysis of such accounts, I, in every case, have taken the precaution of sending the figures to the engineer of each works, in order that he might satisfy himself of their correctness, and in most cases the engineers of these works have very kindly supplemented this figure by the other data required to bring this cost of fuel to a common basis for purposes of comparison.

The best method of comparing the comparative efficiency of the generating plant would be by comparing the weight of water evaporated per unit generated; but as I have already pointed out, when discussing the boiler question, this water measurement has been very rarely carried out, so that I am obliged to fall back upon the only certain measurement—that is, the weight of fuel used. I have written to all the engineers of the works named in these tables, and have, in some cases, received full information, in others partial information, and in a few cases have been refused all supplementary information. In the cases where the information has been partially, or where it has been entirely withheld, I have been obliged myself to fill in the blanks by calculating them from the published costs and known calorific values of the fuel used. I have done this after having made careful enquiry in each case, and whenever there has been a doubt as to quantity, price, or calorific value, I have endeavoured in each case rather to favour that particular works. At any rate, any errors that may exist in these calculated figures cannot be large enough to affect the result which I now bring before you.

(*To be continued.*)

An ordinary general meeting of this society was held on Thursday evening, April 12th, Mr. R. E. B. Crompton, Vice-President, in the chair. The formal business having been transacted, Prof. Ayrton read an addition to the paper read at the last meeting by himself and Mr. T. Mather on "A Universal Shunt Box for Galvanometers."

Prof. Ayrton said: Since the paper was read there had, of course, been criticisms of the method they proposed for shunting. One of the criticisms was mistaken, because it was based really on a wrong conception of the way in which shunts were used. The objection that had been made was this: in fig. 4 (Electrical Review, April 6th, page 409), the method they proposed, the current that passed through the galvanometer, the largest current, was less than the current in the mains. When the main, M_2, was moved to the dotted position no doubt the current then passing through the galvanometer was $\frac{1}{10}$th of what previously passed, but not $\frac{1}{10}$th of the current in the main. Therefore it was contended that the method was not capable of very great application. That would be valid if Thomson reflecting galvanometers were instruments of invariable sensibility and were provided with direct reading scales graduated in microampères. But, as they all knew perfectly well, owing to the change of astaticism of the needles from day to day, the change of position of the controlling magnet and of the masses of iron in the neighbourhood, the constant of the Thomson galvanometer had to be taken whenever they had to use the instrument. Now it was just as easy to take the constant of the arrangement with the resistance, r, shunting galvanometer as when there was no resistance, r, shunting the galvanometer. There was nothing like an example. He had two currents that he wanted to compare: one was a current of one microampère, the other was a current of x, the value of which he did not know. He would take his own method first. The microampère was the microampère in the mains. When one microampère passed along the main the deflection was 536·7. This was the result of actual experiment, of course. Then sending the current, x, through the main, a current much larger than the first, he changed the position of the main wire, and found the deflection to be 536·6, and he knew that the ratio of those two currents in the mains was the ratio of those numbers; that was, the second current was 99·99 microampères. As a matter of fact the true relation of those two currents was exactly 100. The currents were made so that one was exactly 100 times the other, without any reference whatever to their universal shunt box. Now, let them consider the ordinary method. In the ordinary method they would send one microampère through the galvanometer without a shunt, and thus they obtained a deflection of 590·6; then, putting the $\frac{1}{99}$th shunt, whose resistance was nominally $\frac{1}{99}$th of that of the galvanometer, and the deflection obtained was 588·4. One current was thus 99·63 times the other. That was not so accurate. This shunt was made of copper, and was supplied when the galvanometer was bought; it was by a good maker. It was screwed down close to the galvanometer, and had been so for years. It had been kept in a basement, where the temperature did not vary very much, and still the comparison of the two currents with the same galvanometer was not as accurate, using this shunt supplied with the galvanometer, as the comparison of the same two currents using their universal shunt, made without any reference whatever to this particular galvanometer, the coils having been wound by a person who had never seen the galvanometer, and knew nothing of its resistance. All the uses of a Thomson reflecting galvanometer were either to measure two currents or to measure two rushes of electricity. They might be comparing two resistances or two E.M.Fs., but it all resolved itself into comparing two currents in the main or two rushes of electricity in the mains. He would take two condensers. Taking the ordinary method first, one condenser having $\frac{1}{3}$rd of a microfarad capacity, the other unknown, but somewhat larger, both charged with the same E.M.F., and discharged successively through the same galvanometer. The discharge from the smaller condenser through the galvanometer unshunted, gave a deflection of 540·5. Before discharging the second condenser the galvanometer would be shunted. When the galvanometer was shunted with the same $\frac{1}{99}$th shunt, the deflection was 637. If they simply took the swings the apparent ratio of the second to the first was 99·38. As a matter of fact, the second capacity was somewhat greater than 100 times the first, the true ratio of the capacities being 103·45. It was stated in the criticism he was referring to that shunts had a definite damping constant—ordinary shunts, of course. He was not quite sure what that meant. But if it meant that the same correction was to be applied in all cases, then it was wrong. Moving the controlling magnet from the position it was in to another position a little further up, and performing exactly the same experiment, with the same galvanometer and the same ordinary $\frac{1}{99}$th shunt, the ratio of the swings was 91·87. Not only were both these wrong, but they were not wrong by anything like the same percentage. One was 3 or 4 per cent. wrong, and the other about 12 per cent. Now, taking their shunt, which was not made for this particular galvanometer, they got a ratio of 103·5 for the capacities when the controlling magnet was down, and 104 when it was up. Therefore, those two results obtained with their universal shunt box were practically the same; and not only were they both the same, but as the true ratio was 103·45, they were both right, that was to say, no correction would have to be applied, and they got much more easily an accurate comparison of two condensers in this way than in the ordinary way. Mr. Hockin's mathematical analysis showed that the error in comparing capacities with the ordinary shunt depended on the position of the controlling magnet, and therefore the correction which had to be applied for one position of the controlling magnet was quite different from the correction which had to be applied for a different position of the controlling magnet, but he did not think that this difficulty was generally recognised. He thought, therefore, that they were justified in saying that this method was more universal and gave much more accurate results than the shunt which was specially prepared for a particular galvanometer. Now, how about price? Well, he had got estimates of the prices of making shunts, and with very interesting results. First, he took the galvanometer referred to in the paper, simply because it was referred to, a 1,000-ohm galvanometer. What would it cost to make three shunts, right to $\frac{1}{10}$th per cent? The resistances, of course, of the three coils of the ordinary shunt were 111·1 ohms, 11·11 ohms, and 1·111 ohms. How much would it cost to make universal shunt boxes having coils 10 ohms, 90 ohms, and 900 ohms—that was to say, with a total resistance of 1,000 ohms? How much would it cost to make universal shunt boxes with 100, 900, and 9,000 ohms? He would go further: how much would it cost to make universal shunt boxes with 1,000, 9,000 and 90,000 ohms? That was taking 100,000 ohms as the total resistance, and dividing it into three parts. Now, the cost of this last shunt box, partly owing to the much greater ease of adjusting resistances, for you wanted nothing less than 1 ohm to get correct for $\frac{1}{10}$th per cent., was exactly the same as the estimate for the ordinary shunt box for a 1,000-ohm galvanometer. This universal shunt box might be applied to a hundred galvanometers, whether of 100 or 5,000 ohms, or

anything in between. The firm he consulted said they would make a second universal shunt box for 10s. less than the ordinary one for the 1,000-ohm galvanometer. Now, 10,000 ohms was quite large enough for the total resistance of a universal shunt box for a galvanometer of about 1,000 ohms, so that a universal shunt box constructed in the way they proposed could not only be used with a number of different galvanometers, and in each case with a greater accuracy than a special shunt constructed in the ordinary way for each particular galvanometer, but this universal shunt box was actually cheaper than the ordinary shunt box. He thought this was additional confirmation of the fact that this method had many advantages.

Mr. Charles Bright said at present Prof. Ayrton's shunt had one doubtful feature. By his arrangement they would not have the full advantage of using a sensitive Thomson galvanometer for testing high resistances, because he should say that when they had this shunt permanently in multiple arc with a galvanometer they would do away with the usefulness of an exceedingly sensitive galvanometer. There were many cases where they wanted the most sensitive arrangement possible for testing high resistances, whether with a short length of wire or anything else.

Prof. Ayrton said Mr. Bright was perfectly correct. In cases where the current to be measured was so extremely small that to detect it at all bordered on the limits of the possibility of using the galvanometer, it was certainly better to have no shunt to your galvanometer or to have the value of r very large. They must remember that if r had 100,000 ohms it was pretty large compared with galvanometers of 5,000 or 6,000 ohms. Still, it was quite right that if the current was so extremely small that you could hardly detect it, it was better to take away all shunt. But that was very exceptional generally with the delicate galvanometers of the present day, and having a fair number of cells, for when testing the insulation of a condenser or the resistance of a piece of gutta-percha cable they were not, as a rule, measuring currents bordering on the limits of the power of the galvanometer, and in that case if the resistance of r was fairly high compared with the resistance of the galvanometer, he did not see any objection to having the galvanometer, g, permanently shunted with a resistance r.

The Chairman said they would now take the discussion on the paper of Prof. Ayrton and Mr. Whitehead, on "The best resistance for the receiving instrument on a leaky telegraph line."

Mr. Granville said Prof. Ayrton and Mr. Whitehead had laid down a law that the best resistance for the receiving instrument should equal that of the line as measured at that end, the distant end being put to earth. Might he suggest the following addition? That the measurement be made with a duration of contact approximately equal to the duration of contact used in signalling. This was especially important in the case of submarine cables, for it was clear that what they wanted to know was the combined resistance not as measured after, say, one minute, but the combined resistance, as measured after a minute fraction of a second, so as to make it comparable with signalling conditions. They all knew how rapidly in submarine cables the dielectric resistance increased during the first minute of contact with the battery, and, therefore, they could quite clearly see that at the first moment of contact, as in signalling, the dielectric resistance might be even less than that of the conductor. Therefore it seemed that some such addition might be of use.

Prof. Hughes said it was quite a treat to hear a telegraph paper read there—it was so long since they had had one. He had already told Prof. Ayrton that he did not like the title of the paper, because he thought it might be a misleading one to those who did not understand what it really meant. The "best resistance" would evidently be none at all. What they wanted was conductivity, and they wanted the least resistance possible in the electro-magnet, provided they could get the magnet to do what they wanted it to do. He thought all tests of an electro-magnet should be made under conditions such as those in which they were used, particularly with rapid instruments on lines. He made a special study of the subject many years ago for his printing telegraph. The law then in general use, and he had seen it published since, was that the resistance of the receiving magnet should be equal to that of the line. His first magnet was so constructed. He always doubted that, and made a special course of experiments to see whether it was so or not. He found, of course, that the self-induction of the magnet induced an apparent resistance also, and the resistance of the magnet would be enormously great. If they took an electro-magnet that was designed for a line of 500 miles, he found the best under all conditions of losses and heat was to have the electro-magnet $\frac{1}{4}$th of that resistance. If the resistance of the line was very low through losses, he reduced it down to $\frac{1}{10}$th. His telegraphs were constructed for lines of 5,000 miles, and he had 1,250 ohms resistance, but that was so arranged with the shunt that it passed the current parallel through them or in series, so that they could use it with 1,250 ohms, or 312 only. The occasions were very rare when the 312 would not act as well as the 1,250. He was quite convinced that all the receiving instruments throughout Europe were too high. The principle which he had adopted throughout in his instruments was to reduce the resistance as much as possible, and he had experimented on lines of thousands of miles in length. These experiments were not laboratory experiments, but involved watching days and days and months and months to see the effects on each line, and he had never met with a case where a large resistance, equalling that of the line, would work as well as one which was a quarter of that of the line. Therefore he thought it was a great mistake to have too high a resistance in the magnet. The tendency of Prof. Ayrton's method would be to lower the resistance of the magnet, and it would be following very much the same course as he had done, but they must not construct electro-magnets altogether for a bad line. There were times, fortunately, when the lines were good. It used to be a rare thing, but it was general now. In the olden times they were very glad when they could get through any signals at all, the losses were so great through bad insulation. But when they designed electro-magnets for telegraph instruments they could not state any given law for one electro-magnet, because telegraph instruments were all constructed up to a certain model, and the models were thrown indifferently all over the country, one working over 500 miles, one over 300, and one perhaps on a short circuit. Makers never knew where their instruments were going, and the telegraph people did not pay any attention to the resistance. So the makers had to try and find out the average length of line and the average conditions, and design their electro-magnets to meet the average conditions. He had found, within certain limits, a resistance of 312 ohms for 5,000 miles to be the best. But they were troubled not only with losses in the line. In making laboratory experiments they were making fictitious losses and did not get all the conditions of the line. In actual work they had induced currents, earth currents, and so on, and there was one wonderful state of affairs which he had noticed only in southern countries. In England we had rain and earth currents; but when they got to Spain and Turkey, and other hot countries, where the lines were perfectly insulated, if they were using rapid instruments, there would be a sudden jerk, a sudden current, not an earth current and not prolonged, but sufficient to entirely reverse the signal sent if it were a short signal. One of the earliest conditions under which he used to work was to spread a great many losses, just as Prof. Ayrton did, all over the line, and he came to very much the same conclusion; but he did not know what resistance Prof. Ayrton would choose for a 5,000-ohm line. His paper was not very clear with regard to that, but he thought if he were to go over 312 ohms he would make it a little too much, because it was advisable also to work the line for when it was in good order.

Prof. Ayrton, in replying, said he was sorry that, after what the telegraphists had said so often as to their interests being neglected, and that they never had telegraphic papers, and so on, they did not come forward and discuss a telegraphic paper when one was read. If they would only come and say that the paper was wrong it would be something. He did hope to have drawn the telegraph men. Of course, in presenting the paper they did not wish it to be supposed that in the long practice of telegraphy people had not got some notions of what was the best sort of resistance to give the receiving instrument. He remembered that the late Mr. Schwendler, 22 years ago, published a rule that the resistance of a telegraph relay should be equal to $\frac{5}{8}$ths of the true resistance of the line wire. That did not mean the resistance tested as he had described, but the true resistance of the wire neglecting all leakage. That rule was obtained by taking the mean of what would be the best resistance: First, if the line were perfectly insulated; secondly, if there were dead earth in the middle of it, and from those two considerations, two comparatively easy cases, he arrived at the conclusion that the best resistance for a telegraph relay should be $\frac{5}{8}$ths of the true wire resistance, which might come to about the same rule as their own in certain cases. He was not aware, however, that this problem had ever been examined mathematically in a perfectly general form, so that the solution should be applicable to any law of distribution of leakage along the line. A step had been made towards a solution by Mr. Everett, a pupil of his; but it was not until last autumn that Mr. Whitehead and himself saw how to attack it generally. It was this mathematical solution and the extremely easy rule that it led to that formed the subject of the paper. As Professor Hughes had said, the title was perhaps a little misleading. It might appear that a telegraph instrument, was better with a certain resistance than if its coils were wound with wire of infinite conductivity; but inasmuch as a number of convolutions on an electro-magnet was a good thing, while resistance was a bad thing, and as with no material could they obtain convolutions without resistance, there was a certain resistance which was the best for the instrument under particular conditions, and as they had shown, generally the best resistance was the apparent resistance of the line as tested at the receiving end and put to earth at the sending end. The question had been asked, what was the good of obtaining a rule which depended on the insulation of the line? The insulation of the line changed from day to day, and they could not be perpetually altering the resistance of their receiving instrument. The answer was, when the line was in good order and the insulation high, there was no difficulty in signalling; it was only when the insulation was low, through, for example, there being rain along the line, that the trouble occurred. Then he thought it would be best to adapt the resistance of the receiving instrument to suit the line in its worst normal condition, when the leakage was greatest and not caused by a temporary fault which could be removed. Professor Hughes had asked what resistance he would give to an instrument if the resistance of the line was 5,000 ohms. He was not quite clear whether the wire alone had a resistance of 5,000 ohms, or whether this was the apparent resistance. If the wire was 5,000 ohms, he could not answer the question, because it depended on the insulation. He thought he would find a good deal higher than 300 ohms would be good for the resistance of the relay. At any rate that was the conclusion they came to experimentally in India, because, as a matter of fact, there they did make the resistance of the receiving instrument right for each particular line. They did not make a number of instruments with an average resistance and send them out so that the instrument for a line, 50 miles long, had the same resistance as those for lines working across the country from Calcutta to Bombay. In the latter case the relay had several thousands of ohms, and they found it better to increase the resistance. In fact, they were suffering, originally in India, from the relays having much too low a resistance. He thought, perhaps, the difficulty Professor Hughes referred to in hot countries arose from the discharge of the line acting as a condenser. They had a good deal of trouble, 20 years ago, in India from that cause. If the line were long, and the insulation high, the line became a very fair condenser—the overhead wire he meant—and they would then get a return signal from the line. (Professor Hughes: No: it was during continuous work. There would be an interruption every minute or so, perhaps every five minutes. One signal would be lost among a great many.)

Prof. Ayrton: If it arose from the cause he suggested, the interruptions would, of course, be much more frequent. But he thought that capacity might have been the cause of the trouble, as they had found it so in India, which, like Spain, was a hot country.

Prof. Ayrton next read papers on "Transparent Screens for Electric and other Apparatus," and "An Astatic Station Voltmeter," by himself and Mr. T. Mather. It was decided to take the discussions on the two papers conjointly.

Mr. Mordey thought the open scale arrangement of the voltmeter described was the most important feature that had been brought out in direct reading instruments for a long time. Most of them had tried repeatedly to get instruments that had that feature. Instrument makers had as a rule divided their scales to get proportionalities in the scales; proportionalities were very nice things when you had got them, but it was often more important to have a very large and open scale. By the use of a lens, or telescope, one could get quite as good a reading with that instrument, he supposed, as with the much more expensive reflecting instrument, without all the inconveniences of lamp and scale, and the necessity for darkness of the latter. He hoped the authors would pursue their labours further and give them alternating current voltmeters with the same features. This was a permanent magnet instrument, and only suitable for currents not yet quite absolute; but still they would like to have the same features in alternating current instruments.

The Chairman (Mr. Crompton) said the phenomena of the electrification of the glass of instruments was very well known to every apprentice in an electric light station, and the way of preventing it becoming a serious nuisance was also well known. It was, after wiping the glass, simply to touch it with the finger. So far as he knew, no inconvenience had ever arisen from the phenomena; it was, in fact, rather interesting, and rather a show thing, to get the instruments to act, as they had been made to do that evening by being carefully warmed up by means of the lamps in front of them. He did not think Prof. Ayrton would have got the phenomena at all but for the fact that we had been having weather more like that usual in the South of Spain than the old-fashioned English spring. But this was only in passing. No doubt the phenomenon was a defect, and one which showed itself very strongly in electrostatic instruments. In those cases it might be a very great nuisance, and they were greatly indebted to Prof. Ayrton for following the matter out. He thoroughly agreed with the points raised as to the requirements of a good station voltmeter. But he fancied that Prof. Ayrton had but carried out what many of them had carried out before, and that some of his improvements were not new. The pointer which he had described was identical with the form which his firm had used for some time past. The clamping device appeared also to have been used by them and others. The way in which Prof. Ayrton got over the difficulty by using a moving coil, which was a very beautiful development of Mr. Weston's method, had only one serious defect, that it was so costly. Mr. Weston's instruments were so costly that it was a luxury to have one in each station, and he was afraid that when they multiplied Mr. Weston's coils by three and applied as much care to producing the three permanent magnets as Mr. Weston applied in producing one, it would be found that the instrument was so costly as to be scarcely within the reach of many of them. It was for that reason that they had all been trying to make practical astatic instruments in a simpler way. The voltmeter of modern times had to be made and sold for £3 or £4, and he did not think Prof. Ayrton's instrument could be made and sold, properly calibrated, for so small a sum as that. By employing instruments with soft iron deflecting pieces, as astatic as possible, so as to provide them with an exceedingly strong field, they did now get results sufficiently good for their purposes, which were—to have in the station one very good electrostatic voltmeter, either a Sir William Thomson's multi-cellular form, or something resembling that, and have that as the voltmeter for reference, and have a large number of voltmeters on the switchboard, sufficiently close to the reference voltmeter, so that the errors at different times of the evening might be known and noted. The errors might be 1 per cent. or 1½ per cent.; but those who were working at the switchboard were accustomed to them and could make allowances for them. They found no difficulty in obtaining voltmeters for small sums which were accurate within that limit of error. He would point out to Prof. Ayrton that he would not make a very sensitive instrument with the three coils arranged in the way he described, for the weight of those coils was something considerable, and with the balancing weight added would be so much for the pivot to carry that the instrument would be much more sluggish than one with a deflecting piece, that deflecting piece acting as the weight, or else having an additional weight of small magnitude. As regards the open scale, he thought equally open scales had been obtained by several people. Mr. Mordey said he required an equally good instrument for alternate currents. He (Mr. Crompton) thought he would have no difficulty in getting that instrument, because so many people's minds were now being directed to electrostatic voltmeters for alternating currents, and such excellent results had been obtained that he thought they would find they could get instruments for alternating currents as good as, or even better than, for continuous currents, and with the beautiful addition of Professor Ayrton's transparent conducting varnish they would be absolutely perfect for their purpose.

Prof. Ayrton, in replying, said Mr. Crompton rather implied that he had manufactured a defect in the measuring instrument, and then shown how to get over it, and that it was rather a feat to show the defect. Now, Mr. Mordey was not, as a matter of fact, the first to draw his attention to this electrostatic action, because in a certain central electric lighting station in London of no small importance, he was shown, four years ago, a row of these instruments, and was told they could not be used because of the difficulty that the pointers were always attracted when they cleaned the glass. He believed a good many of those instruments still hung on the switchboard but not in use in that station. Mr. Crompton said it was quite easy to get over the difficulty—you had only to touch the glass with your finger. Curiously enough, a central station engineer had written to point out the bigger effect produced when the glass was touched with the finger. He went on to say—which was wrong reasoning, for occasionally even central station engineers did reason wrongly—I think you will have to put varnish outside as well as inside the glass, because not only do you get an effect when you rub the glass, but you get a much bigger effect when you touch it outside with your finger. It was not an easy matter to de-electrify glass by simply touching it with the hand. As regards warmth, that was, of course, the difficulty. If in central stations they did not waste their heat, but kept their voltmeters cool, they might be able to keep them right; but with the warmth they could not avoid having in a central station the instruments were as dry as, if not drier, than the instruments he had on the table with the glow lamps in front of them, and the effect was as noticeable. As to the clamping device, it was fair to themselves to say that they had used this particular device in connection with their electrostatic voltmeters, which were not the subject of the paper before them, for some three or four years. Mr. Crompton said the use of a moving coil with a permanent magnet produced a sluggish instrument. In that he might say without hesitation that Mr. Crompton was absolutely wrong, because it was well-known that you could increase the force to any amount you liked if you only had a sufficiently powerful permanent magnet. The proof was that the watts employed in this instrument exhibited were only 1½ at 100 volts, and they got a pretty quick motion of the needle. It was the fact of Mr. Weston using the idea of using a moving coil and a powerful permanent magnet which enabled him to make voltmeters of very high resistance. No portable voltmeter was ever made of over 10,000 ohms before Mr. Weston made his. How did he obtain it? Mr. Swinburne suggested that Mr. Weston had even made one of 100,000 ohms for 100 volts. How? Simply by utilising the principle that Maxwell was the first to point out, and that Lord Kelvin had utilised in his siphon-recorder, because he wished to get a big effect with a small expenditure of energy, a large magnet and a small coil. They did not use any controlling weight in their own instrument; they used a weight to control it, but not an auxiliary weight. The weight was the weight of the coils themselves, and they had said that with 3 per cent. of the whole resistance they could get force enough to give a sufficiently quick motion. Three coils would give them more effect than only one coil and without triple amount of friction at the pivot. In reference to the price of the instruments, it must not be forgotten that the Weston instruments were made in America. American workmen were paid twice as much as workmen here, and they were able to keep up those high prices because of the very heavy import duty levied on goods coming from other countries. They must not therefore jump to the conclusion that because the Weston instrument was an expensive one other instruments using a moving coil must be equally expensive.

NEW PATENTS—1894.

7,050. "Improvements in electrically illuminated signs." G. C. Fricker. Dated April 9th.

7,054. "Improvements in electrically propelled vehicles." E. J. Clubbe and A. W. Southey. Dated April 9th.

7,080. "Improvements in phonographs." J. Oulton. Dated April 10th.

7,094. "Improvements in and connected with secondary electric batteries." W. J. S. Barber-Starkey. Dated April 10th.

7,116. "Apparatus for calling any desired station on a telegraphic or telephonic line." C. Bradbury. (Communicated by F. Trinks, Germany.) Dated April 10th. (*Complete.*)

7,121. "Improvements in electric car lighting apparatus." W. Biddle and P. Kennedy. Dated April 10th.

7,130. "Improvements in or connected with means for transmitting and recording the transmission and receipt of signals made by flashes of light or other visual signs." J. B. A. Lege, J. C. E. Carre, and M. L. Isaacs. Dated April 10th.

7,132. "Improvements in microphones." H. Carbonnelle. Dated April 10th.

7,145. "Improvements in or connected with the electro-deposition of metals or metallic compounds, and the treatment of deposited metals or compounds." S. O. Cowper-Coles and B. W. Walker, Bart. Dated April 10th.

7,148. "Governors for electric, water, and other motors." N. S. Keith. Dated April 10th.

7,155. "An improved multiple distributing electric cut-out." A. Higgins. Dated April 10th.

7,165. "Improvements in secondary voltaic batteries." E. J. Clubbe and A. W. Southey. Dated April 10th.

7,176. "Improvements in and relating to telephonic systems." H. Carbonnelle. Dated April 10th.

7,205. "A new or improved process for the electro-deposition of aluminium and aluminium alloys." A. F. B. Gomess. Dated April 11th.

7,206. "A new or improved process for the electro-deposition of aluminium and aluminium alloys." A. F. B. Gomess. Dated April 11th.

7,214. "Improved safety arrangement for electric miners' lamps." H. V. Coad. Dated April 11th.

7,215. "Improvements in electric printing telegraphic apparatus." E. Magnin. Dated April 11th. (*Complete.*)

7,216. "An improvement connected with electric switches." R. Hurst. Dated April 11th.

7,221. "Improvements in gas and oil motor engines." W. Le P. Webb. Dated April 11th.

7,238. "Improvements in or relating to electric telephones." Sir C. S. Forbes. Dated April 11th.

7,239. "Improvements in alternating current electric motors." C. Coerper. Dated April 11th. (*Complete.*)

7,240. "Electrically propelled common road vehicles." W. C. Bersey. Dated April 11th.

7,244. "Improvements in apparatus for electrically recording circular, longitudinal, or transverse motions of mechanical devices." W. H. Akester, and H. H. Price. Dated April 11th.

7,258. "Improvements in electric arc lamps." G. Binswanger, and H. J. Coates. Dated April 12th.

7,287. "A method of electrically lighting vehicles by their own momentum." S. Robson. Dated April 12th.

7,294. "Improvements in gas and like engines." J. Farmer. Dated April 12th.

7,307. "A new or improved electrical appliance for sounding an alarm when any desired temperature is reached, also serving as a fire alarm." C. Balbiani. Dated April 12th. (*Complete.*)

7,311. "Improvements relating to secondary batteries." B. A. N. Dorez. Dated April 12th.

7,322. "An improved electric central alarm or call apparatus." C. Christgau. Dated April 12th. (*Complete.*)

7,396. "An electric contact apparatus worked by railway trains." E. Tyer. Dated April 13th.

7,402. "A new or improved gas or electric light regulating apparatus for railway stations." L. B. Tappenden. Dated April 13th.

7,467. "Improvements in primary electric or secondary batteries." A. J. Marquand, and E. Hancock. Dated April 14th.

7,468. "Improved method of and apparatus for distributing electrical energy by means of alternating currents." E. Arnold. Dated April 14th.

7,477. "Improvements in apparatus and means for vulcanising small articles, more especially intended for vulcanising the insulation at the joints of electric conductors." H. Edmunds. Dated April 14th.

7,479. "An improved electricity meter for registering the amount of current consumed on direct, or alternating, polyphase, triphase, or quadruplephase circuits." F. J. Beaumont, and F. Hallows. Dated April 14th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1893.

601. "Improvements in and relating to the manufacture of electric incandescent lamps." J. R. Hughes. Dated January 11th. Consists in making the globes of glass to take a stopper at its sealing in end, which consists of a tapered neck, and fitting into the said neck a stopper, friction tight, made of a composition such as rubber, asbestos, or both, through which are carried the leading-in wires. 3 claims.

775. "Improvements in electric arc lamps." E. Conrady. Dated January 13th. Relates to an arrangement of differential or compound levers which are to be operated by the core of a solenoid or the armature of an electro-magnet for regulating, as by lowering or raising, the carbon or carbons of an arc lamp as the condition of the arc thereof from time to time requires. 6 claims.

1,416. "A new or improved electric alarum for use in hotels or other large buildings, or otherwise." L. G. Weygang. Dated January 23rd. By the use of this invention any one in any number of chambers can be effectually called at any predesired time. 1 claim.

1,579. "Improvements in connection with electric bells." L. G. Weygang. Dated January 24th. Consists in attaching a sort of pendulum, preferably in an upright position, to the hammer of the bell. 1 claim.

1,661. "Improvements in electrolytic apparatus." E. Andreoli. Dated January 25th. Refers to the employment of porous conducting diaphragms, the control of the electric current passed through them and the protection of the material of which they are composed. 3 claims.

1,683. "Improvements in electric arc lamps." F. G. Lott. Dated January 25th. The inventor connects the top of the solenoid to the inside upper portion of the frame of lamp, the wire from the solenoid is continued round a cut-out magnet suitably fixed in lamp, such wire is then connected with one of the main terminals of the lamp, and one end of shunt wire is connected with the other main terminal of the lamp, and the other end of shunt wire is connected with the cut-out, so that in the event of the carbon rod hanging up, or the carbon breaking, the shunt is immediately opened by means of the cut-out. 3 claims.

2,272. "Improvements in electric light hangers or supports." H. L. Holt. Dated February 1st. The improved hanger is so constructed that it not only entirely incloses and conceals the electric wires, but also provides means whereby the electric lamp can be adjusted in a variety of different positions, as for instance drawn down, pushed up out of the way, or moved to the right or left—and will stay rigidly in such position until it is desired to move the same into another position. 6 claims.

3,118. "Improvements in electrical conductors." H. Edmunds. Dated February 11th. The inventor builds up a conductor of the requisite thickness or dimension by plaiting layers of fine wires or strips preferably in the form of tubes one over the other. In order to give the article so formed great density he subjects it to pressure in devices which give thereto the requisite cross sectional shape and size of the required conductor. 1 claim.

3,119. "Improvements in the formation of solid ends on flexible or compound electrical conductors." H. Edmunds. Dated February 11th. Has for its object to form solid ends on flexible compound conductors and is more especially intended for application to conductors which are to be used for armature windings. Metal is applied at the requisite temperature to the ends of the wires or strips. This is most conveniently effected by introducing the ends of the wires or strips to be connected into a mould of the form and size which the solid ends are to have and introducing molten metal into this mould. 1 claim.

3,152. "An improved electrical pendulum indicator." E. Beal. Dated February 13th. Claims:—1. An electrical pendulum indicator, substantially as described, having for its armature a permanent magnet. 2. An indicator as described in which one screw forms the magnet core, fixes the armature holder, and also fixes the movement to a case.

7,600. "Improvements in electrical heating apparatus." Sir D. L. Salomons. Dated April 14th. Consists in the arrangement of a heater constructed of such shape, form, and size, as to readily pass through the orifice in the said vessel or chamber, which is, or may be, used for the introduction or withdrawal of the substance to be heated. 4 claims.

8,176. "Improvements in electrolytic apparatus." C. Hanbury. Dated April 22nd. Relates to improvements in the construction of electrolytic tanks and arrangements whereby the electrolyte is made to circulate and is otherwise dealt with without interference with the electrolytic operation. 5 claims.

16,000. "Improvements in telegraphy." C. A. Allison. (Communicated from abroad by P. J. Wicks, of Brooklyn.) Dated August 24th. The invention is intended to avoid reversals of magnetism in the core of the neutral quadruplex relay, by instrumentalities controlled by the to-and-fro currents themselves, the means employed serving to so direct the alternating pulses as to create or maintain one direction of magnetic effect, or to avoid reversals of magnetism in the relay core or cores. 5 claims.

16,226. "Improvements in electric cars." E. Egger, F. A. Wessel, and A. Naumburg. Dated August 29th. Consists in the use of a constant speed motor in connection with a variable gear. The easy riding of the car is attained by reducing the friction of the axle box guides, and by utilising a flexible gear to connect the motor to the car wheels. 26 claims.

18,064. "Improvements in electric switches." The Edison and Swan United Electric Light Company, Ltd., and P. H. Bell. Dated September 26th. Relates to the construction of an electric switch (which may be in the form of a switch to be fixed against a wall or of a pendant switch), in such a manner that one push of the button or stud makes and the next push breaks contact, and so on alternately. 1 claim.

18,990. "Improvements in the method of and apparatus for electrically heating or working metal or other materials capable of momentarily withstanding the heat of an electric arc." W. P. Thompson. (A communication by C. L. Coffin, of Detroit.) Dated October 10th. The operation of this device is as follows:—An electric current being passed through conductors, material, and carbon, by lowering the carbon into contact with material and then raising it, a voltaic arc will be formed between said carbon and the material. A current also passing through an electro-magnet magnetises a core. By rotating a collar, and with it an arm of the core, said arm travels round and round said carbon, and according to its polarity either attracts or repels the voltaic arc, which travels round and round, either following or receding from arm, thus causing said arc to affect a much larger portion of the material than is due simply to its normal size. 8 claims.

20,408. "An improvement in or applicable to ear-pieces for telephone-receivers." J. W. Kinniburgh. Dated October 28th. Comprises a pad of special construction which can be attached to the outer face of an ordinary telephone-receiver by means of suitable clips, or can be manufactured as part of the same; the object of the invention being to render the surface which is presented to the ear readily renewable. 1 claim.

20,715. "An electrical healing apparatus." W. E. F. Ruckert. Dated November 1st. Relates to an apparatus for producing waves or vibrations of electricity within a closed space for the purpose of healing certain ailments such as headache, tooth-, ear-ache, neuralgia, &c., when the parts of the body affected are brought into close contact with these waves. The invention rests on the scientifically proved fact, that so-called long waves are produced when an electric current is made to pass between two wire points placed at a small distance from each other. 3 claims.

22,312. "Improvements in storage batteries." E. P. Usher. Dated November 21st. Relates to storage batteries constructed of a plain sheet of lead of the desired shape, and certain separator sheets consisting of wood, earthenware, or any equivalent porous substances, together with spacers, or end pieces, to hold the other parts in proper position, and a filling of active material. 9 claims.